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COMMUNICATION ON AN ANTIQUE STONE HAND-HAMMER. By F. Peale.*

In a late work, entitled "Geological Evidences of the Antiquity of Man," by Mr. Lyell, page 184, there is a description, illustrated by a wood-cut, of a cave situated on the side of a hill near Aurignac, department of the Haute Garonne, France; with a description of the bones of various animals found therein, associated with the works of man, as well as remains of his osseous structure.

Among the articles was one thus described by him: "Outside the entrance was found a stone of a circular form, flattened on two sides, with a central depression, composed of a tough rock, which does not belong to that region of the Pyrenees. This instrument is supposed by the Danish antiquarians to have been used for removing by skilful blows the edges of flint knives, the fingers and thumb being placed in the opposite depressions during the operation."

A similar instrument was lately added by myself to the cabinet of the Society as a "*hand-hammer*" (a drawing of which accompanies this communication). See Plate vii, Fig. 1.

This instrument is submitted to the personal inspection of the members. It will be observed that its entire correspondence with the description by Mr. Lyell of the specimen found near the cave at Aurignac, France, is so perfect, that it might, without explanation or exception, have been applied to the specimen before you, which was found in Monroe County, Pennsylvania.

This specimen is also interesting from the evidence it exhibits of the process of "*pecking*" (as it was called in a communication made to the Society in June, 1861), to form the cavities for the reception of the thumb on the one side, and the finger on the other. It also bears the mark of its use upon silicious minerals at each extremity; and it may, with little risk of error, be supposed to have been used in fashioning the flint arrow-heads of the *Stone Age* on the spot where it was found.

These implements are not rare in this country. A number are contained in my cabinet, and many specimens have been sent abroad for foreign exchange; but, as they present to an unaccustomed eye little difference from an ordinary pebble, it is only lately that they have attracted the attention of collectors; yet the remarks of Mr. Lyell

* Read April 15, 1864.

give evidence that they have not escaped the observation of those close and learned investigators, the archæologists of Denmark.

These implements, as far as my observation extends, have been hitherto entirely neglected in this country; but that is not so much a matter of wonder, when we know that the arrow and spear heads, so frequently found, are generally regarded as relics only, or the poor weapons, of the despised and degraded Indians, who formerly roamed in savage independence over these their hunting-grounds, with no thought of their ethnological relations or bearing on the history of the human race, and are therefore held in little esteem.

But may we not, without presumption, hazard a few remarks on a most important deduction to be drawn from the facts now being developed from examinations in nearly every part of the world? The close, nay exact similarity, of all these implements, derived as they are from regions far apart in space, in various climates, and, more singular still, from periods so remote from each other as to carry up archæology into the domain of geology; the implements of the former being so imbedded with the *debris* of the latter, that to assign a determinate age to either is probably beyond the reach of human investigation. Entirely prehistoric in their early associations, we find them, together with the bones of the great pachyderms and many other extinct animals, embedded in diluvium, in the earth and stalagmites of caves; and thence we descend from the era when these extinct monsters, the mammoth, the elephant, and the rhinoceros, and numerous rapacious beasts, held coeval possession with man of the river-banks of all climes down to the times which witness the same rude arts of the stone age practised by savages on this and it may be other continents, simultaneously with the arts of the highest civilization; when the instrumentality of the plough, the ship, and the factory furnish all that man's necessity calls for, or his most refined existence seems to need.

During all this interval man obeyed the same instinctive impulses. Even now we take a pebble (no better tool being at hand) to open a spiny chestnut burr, or to crack the shell of a nut. A savage, with no metal to aid him, makes of this pebble a more convenient tool, by pecking, with a still harder fragment of stone, cavities for his fingers; and, in a further advance, cuts a groove around it, in which he binds a *withe* handle, and then grinds its extremity to an edge, thus making the tools which serve all his limited wants, until more enlightened civilization teaches the use of metal.

Now does not all this indicate the UNITY OF HIS ORIGIN? He

naturally and inevitably follows the same course to supply his wants. He chips the flint and silicious minerals to form his spear and arrow-heads; he grinds the various stones to form his *chisels* and *axes;* he moulds the plastic clay to form his cooking utensils; and last, though not least, his aspirations for futurity indicate an innate consciousness of that great and good first cause, the Almighty hand, which formed him of the dust of the earth, and placed him in a beautiful garden, where he might have dwelt forever, if he had not fallen, by his own free will, to roam the earth,—to sink by ignorance and vice, alas! in too many cases, to that state in which STOCKS and STONES were or are his only guides or means,—the one for direction, the other for subsistence.

Stated Meeting, July 15, 1864.

Present, five members.

Mr. CHASE in the Chair.

Letters of acknowledgment were received from the Royal Society, Göttingen, January, 1864; the American Oriental Society, Boston, May, 1864, and the Lyceum of N. H., New York, March 17th, 1864.

A letter of envoi was received from the Société de Physique et d'Histoire Naturelle de Genève, March 1st, expressing a wish for full and regular exchanges, which, on motion of Mr. Fraley, was so ordered.

Letters with photographic likenesses of the authors for the Album were received from Jared Sparks, of Cambridge, Mass., May 28th, and Prof. Zantedeschi, of Padua. Mr. James presented a photograph, also, of Asa Gray, of Cambridge, Mass.

A letter to the Librarian was read from W. L. Nicholson, Esq., Topographer to the Post Office Department, correcting an error in the account of the deficiencies at Washington in the matter of United States county maps, given on page 352 of the Proceedings. Mr. Nicholson has a nearly com-

plete set of them, now on file in the United States Post Office Department, collected under the present Administration:

"On being honored with this appointment last year (coming from the Coast Survey Service), I immediately set myself to collect the best data from all quarters to have for ready reference, and to put everything into good shape, not only to keep up the current work, which is very great, owing to the changing and expanding character of the postal service, but to have the material ready for bringing out, as soon as practicable, postal maps of the United States.

"I need hardly tell you that this is a work of very great labor and nicety, your own State having over two thousand five hundred post-offices, and routes interlacing in all directions. I have more trouble with the locations of the post offices in the older States than with the new; thanks to the Land Office subdivisions.

"The Territories, however, afford choice bits of perplexity, counterbalanced, however, by the feeling of interest in the opening out and clearing up of these terræ incognitæ."

Donations for the Library were received from the Imperial Russian Government; the Imperial Geological Institute, Vienna; Royal Society, Göttingen; Dr. R. Wolf, Zurich; Société de Physique et d'Histoire Naturelle de Genève; Geological Society, Paris; the Royal, Royal Astronomical, Royal Geographical, Chemical, and Geographical Societies at London; Agricultural Society, Bath; Insane Asylums at Concord and Hartford; American Oriental Society; Silliman's Journal; New York Lyceum; Franklin Institute, Mercantile Library, Northern Home, Blanchard & Lea, and P. E. Chase, of Philadelphia; Smithsonian Institution, Census Bureau, and F. W. Seward, of Washington; and the Mercantile Library Company of San Francisco.

The Librarian called the attention of the members present to the superb volumes of the Codex Sinaiticus Petropolitanus, presented to the Society by the Imperial Government of Russia; and on motion of Mr. Fraley, the Secretaries were directed to prepare a special letter of thanks, to be signed by the officers of the Society.

The death of Mr. Benjamin Gerhard, at Philadelphia, on the 20th ult., was reported by Mr. Fraley, and Mr. E.

Spencer Miller was appointed to prepare an obituary notice of the deceased.

The death of Josiah Quincy, LL.D., at Quincy, Mass., on the 1st inst., aged 92, was announced by Mr. Lesley, and Dr. Jared Sparks was appointed to prepare an obituary notice of the deceased.

The death of Thomas Dunlap, Esq., at Philadelphia, on the 11th inst., aged 70, was announced by Mr. Fraley, and Mr. William M. Meredith was appointed to deliver an obituary notice of the deceased.

Mr. Chase read a note on the Daily Aerial Tides that are attributable to the Lunar and Solar Attraction and Variations in Temperature.

The powerful and prejudicial influence of an inveterate scientific error, is shown in the following dogmatical statement of Mr. Joseph John Murphy, an investigator who has lent useful aid to meteorological science.†

In the Edinburgh New Philosophical Journal for April, 1864, p. 183, he says: "Were the atmosphere not acted on by heat, it would be everywhere at rest, and every level surface, at whatever height, would be an isobarometric surface. . . . . The earth's rotation cannot produce currents, but it modifies them when they are produced by the action of heat."

There can be no doubt that heat is one of the causes, and in most places it is, perhaps, the principal cause, of those atmospheric disturbances which are modified by rotation, but the assumption that the atmosphere "would be everywhere at rest," except for differences of temperature, leads to palpable absurdities.‡

It may be freely admitted that Galileo, in attributing the ocean

* From the Proceedings of the American Philosophical Society.

† Mr. Murphy was an early and independent advocate of so much of Mr. WILLIAM FERREL'S theory, as explains the polar depression of the barometer by centrifugal force and friction. Mr. Ferrel's paper, which appears to have been the first publication that contained a true explanation of the equatorial as well as the polar barometric depression, of the maxima near the parallels of 30°, and of the cause of the rotatory motion of storms, was printed in the Nashville Journal of Medicine and Surgery, and afterwards in pamphlet form, in the summer of 1856. The subject was treated at greater length, in his essay on "the motion of fluids and solids relative to the earth's surface," which was published in the "Mathematical Monthly" for 1859, vol. i, p. 140, sqq.

‡ See Proc. Am. Philos. Soc., vol. ix, pp. 283–4.

tides exclusively to "the rotation of the earth, combined with its revolution about the sun," attached too much importance to the simple combination of the motions of rotation and orbital translation, but his mistake is no greater than the opposite belief, which is now too prevalent, that there is only a single influence which can produce any important tidal effects in the atmosphere.

In a former communication on the rotation-tide, I deduced "from a reference of the aerial motions to a supposed stationary earth, a law of tidal variation nearly identical with the law that is derived from a consideration of the relative attractions of two bodies revolving about their common centre of gravity."* That such should be the case, might have been reasonably expected from the dependent connection of rotation and revolution with gravity and inertia.

I was therefore led to believe that the daily lunar barometric tides might be indicated by an expression of the same general form as the monthly lunar and daily rotation tides. On investigation I am gratified at finding that such is indeed the case. If M is the barometric mean for any given day and place, and θ is the moon's altitude, observation and theory concur in demonstrating that the lunar tide may be expressed by M C (sin. θ cos. θ),† C being a constant to be determined for each station, the principal elements of which are functions of the latitude, of gravity, and of time. I subjoin, in illustration, a

TABLE OF THE AVERAGE DAILY LUNAR BAROMETRIC TIDES.

Lunar Hours.	Station.		Lunar Hours.	Station.	
	St. Helena.	Girard College.		St. Helena.	Girard College.
	in.	in.		in.	in.
0	— .00006	+ .00313	6	— .00276	— .00308
1	— .00051	+ .00341	7	— .00242	— .00339
2	— .00172	+ .00291	8	— .00121	— .00290
3	— .00253	+ .00214	9	— .00046	— .00206
4	— .00315	— .00011	10	+ .00021	+ .00013
5	— .00330	— .00144	11	+ .00035	+ .00149

* This is evidently only another form of a single element in La Place's law of the tides. I present it in this shape, both because I obtained it independently, and because it makes the resemblance to my rotation formula more striking.

† Major-General Sabine's table of the lunar tides at St. Helena, from October, 1843, to September, 1845 (Phil. Trans., 1847, p. 48), gives for the ratios of the MEAN, .497, .832, and 1, which, if averaged with the mean at Girard College, gives a general mean of .512, .858, and 1. The GRAND MEAN for the entire periods of observation at the two stations is .500, .849, and 1.

The existence of the tidal law, which, as we have seen, should produce differences in the respective ratios of .5, .866, and 1, at 1, 2, and 3 hours from the mean tide, is shown in the following

TABLE OF TIDAL DIFFERENCES AND RATIOS.

Stations.	Lunar Time.	Differences of Barometer.			Ratios.		
		1 h.	2 h.	3 h.	1 h.	2 h.	3 h.
St. Helena, 1841–46.	Before 2 h.	.00121	.00166	.00207	.585	.802	1
	After 2 "	.00081	.00143	.00158	.501	.905	1
	Before 8 "	.00121	.00155	.00209	.579	.742	1
	After 8 "	.00075	.00142	.00156	.481	.917	1
	Mean, . .	.00099	.00151	.00182	.545	.830	1*
	Mean Ratios,				.536	.841	1
Girard College, 1843–44.	Before 4 h.	.00225	.00302	.00352	.639	.858	1
	After 4 "	.00133	.00297	.00328	.405	.905	1
	Before 10 "	.00219	.00303	.00352	.602	.861	1
	After 10 "	.00136	.00300	.00328	.415	.915	1
	Mean, . .	.00178	.00300	.00340	.524	.884	1
	Mean Ratios,				.515	.885	1
Grand Mean, or Average of Mean Ratios, . .					.525	.863	1

By a partial interpolation for the true time of mean tide at St. Helena, I obtain for the ratios of the means .557, .866, and 1, corresponding precisely with theory at 2h. from mean tide. The tables furnish suggestive evidences of the effect of declination, the varying tidal influence of attraction, when acting with and against rotation, and the resistance of gravity to the tidal flow of air.

The rationale of M. Flaugergues' second and third inferences thus becomes intelligible; the phenomena of ocean tides are connected with those of the atmosphere, which are subject to fewer extraneous disturbing influences, and can therefore be more easily investigated; and the long-suspected obedience of the principal meteorological changes to fixed natural and mathematical laws, is at length made evident.

There are, therefore, manifestly four important causes of barometric disturbance: 1, rotation, with its quarter-daily phases of alternate aid and opposition to the attraction and temperature-currents, and of shifting the aerial particles to levels of greater or less density; 2, variations of temperature and vapor; 3, lunar attraction; 4, solar attraction. Among the subordinate causes, perhaps the next in order of importance is, 5, resistance of the æther, which, according

to Fresnel's theory,* is subject to the laws of inertia and attraction, as well as to those of elasticity. If his theory is correct, the terrestrial æther (or the portion which partakes of the earth's rotation), may be so modified by the planetary æther (or the portion which revolves about the sun), as to produce a resistance varying at different hours, and a consequently varying atmospheric compression, which may some time enable us to measure its own density. The solar attraction may be constantly tending to accumulate the terrestrial æther, as well as the atmosphere, in a spheroid with a major axis in the line of the radius vector, and the position of the axes, as in the case of the ocean and aerial spheroids, may be modified by rotation. It appears to me that one of the most probable results of the rotation of the earth with its atmosphere, in an æthereal medium, would be the production of two systems of oscillations, moving with the rapidity of light, one in the line of the earth's orbit, and the other in the line of its radius vector, and that those systems would be constantly so related that while one tended to retard, the other would tend to accelerate the earth's motion.

The influences of rotation and attraction can be calculated, and after deducting their amount, the problem of accounting for the residual disturbance will be simplified. Or, by taking the average of a long series of observations made at each hour of the solar day, the effects of lunar attraction may be so far eliminated, that they can be safely disregarded in attempting to fix the approximate value of the other principal disturbances.† The formula for the rotation tide has already been given, and observation appears to indicate that it is retarded about an hour by inertia; next in order of importance are the temperature and vapor tide, and the solar tide. It would be presumptuous in the present stage of our investigations, to attempt to fix the precise amount of disturbance which is attributable to each of these two tides, but from the following considerations we may derive

* It is, perhaps, hardly proper to call this "Fresnel's theory," since it follows necessarily from the conception of an extremely tenuous and elastic material fluid, such as the æther is generally supposed to be. But I believe M. Fresnel has done more than any one else to show the agreement of the hypothesis with observed phenomena, and his labors deserve to be kept in honorable remembrance.

† The absence of any long series of observations at each hour of the lunar day, prevents our eliminating the effects of solar attraction in a similar way. Nevertheless, I propose at some future time to attempt the elimination, so far as practicable with the tables at my command, in the hope of thereby effecting a more accurate determination of the temperature and vapor tide.

conjectural results, which appear to me to be more satisfactory and philosophical than any that have been heretofore obtained.

The theoretical maxima of the rotation tide, allowing an hour for the lagging of inertia, occur at 4h. and 16h.; the minima, at 10 h. and 22h. The solar attraction maxima, with the same allowance, should be found at 1h. and 13h.; the minima, at 7h. and 19h. If we assume that the attraction tidal curve is symmetrical, and regard all the deviations from symmetry as occasioned by differences of temperature and vapor, we may readily construct the following approximate

DAILY BAROMETRIC TIDAL TABLE.

	Girard College, 1842–44. Mean Height, 29.938 inches.*				St. Helena, 1844–46. Mean Height 28.2821 inches.			
Astronomical Time.	Observed Height 29 inches +	Rotation Tide.	Temperature and Vapor Tide.	Solar and Residual Tide.	Observed Height 28 inches +	Rotation Tide.	Temperature and Vapor Tide.	Solar and Residual Tide.
h.	in.	in.	in.	in.	in.	in.	in.	in.
0	.943	+ .0126	— .0031	— .0045	.2985	+ .0149	+ .0035	— .0020
1	.927		— .0055	— .0055	.2819		+ .0021	— .0023
2	.915	— .0126	— .0059	— .0045	.2660	— .0149	+ .0008	— .0020
3	.909	— .0217	— .0058	— .0015	.2553	— .0258	— .0003	— .0007
4	.908	— .0252	— .0053	+ .0005	.2521	— .0298	— .0010	+ .0008
5	.911	— .0217	— .0075	+ .0022	.2562	— .0258	— .0015	+ .0014
6	.917	— .0126	— .0124	+ .0040	.2642	— .0149	— .0040	+ .0010
7	.925		— .0170	+ .0040	.2764		— .0067	+ .0010
8	.935	+ .0126	— .0196	+ .0040	.2899	+ .0149	— .0081	+ .0010
9	.942	+ .0217	— .0199	+ .0022	.3063	+ .0258	— .0090	+ .0014
10	.945	+ .0252	— .0187	+ .0005	.3061	+ .0298	— .0066	+ .0008
11	.946	+ .0217	— .0122	— .0015	.3025	+ .0258	— .0047	— .0007
12	.941	+ .0126	— .0051	— .0045	.2913	+ .0149	— .0037	— .0020
13	.938		+ .0055	— .0055	.2777		— .0021	— .0023
14	.935	— .0126	+ .0141	— .0045	.2646	— .0149	— .0006	— .0020
15	.933	— .0217	+ .0182	— .0015	.2562	— .0258	+ .0006	— .0007
16	.934	— .0252	+ .0207	+ .0005	.2550	— .0298	+ .0019	+ .0008
17	.940	— .0217	+ .0215	+ .0022	.2611	— .0258	+ .0034	+ .0014
18	.950	— .0126	+ .0206	+ .0040	.2737	— .0149	+ .0055	+ .0010
19	.959		+ .0170	+ .0040	.2898		+ .0067	+ .0010
20	.966	+ .0126	+ .0114	+ .0040	.3048	+ .0149	+ .0068	+ .0010
21	.968	+ .0217	+ .0061	+ .0022	.3163	+ .0258	+ .0070	+ .0014
22	.967	+ .0252	+ .0033	+ .0005	.3184	+ .0298	+ .0057	+ .0008
23	.958	+ .0217	— .0002	— .0015	.3117	+ .0258	+ .0045	— .0007

Imperfect as these first approximations confessedly are, and probable, nay, almost certain though it be, that a large portion of the residual tide should be transferred to the temperature and vapor column,† yet

* The sum of the tides, + the mean height = observed height.

† I can see no good reason at present, for supposing the existence of a solar tide greater than .002 in., which would be equivalent to .0005, .0009, and .001, at 1,

I think the above table will be found suggestive of valuable inferences, of which the following are perhaps among the most important.

1. That the apparent osculation of the solar and residual curve near the hours of high barometer may perhaps be owing to æthereal resistance.

2. That the cumulative action of the sun upon the air and æther, may possibly render the disturbing influence of its attraction upon the atmosphere even greater than that of the moon.

3. That the paradoxical assumption of those who advocate the temperature theory of the quarter-daily tides, that a dependent relation can exist between the barometrical changes and the changes of temperature, which "appears to be DIRECT during the morning hours, and INVERSE during those of the day and evening,"* is unnecessary, useless, and unphilosophical.

4. That in intertropical and medium latitudes, the average daily barometric tide which is attributable to variations of temperature is smaller than the rotation tide.

5. That there is but one high and one low temperature tide in twenty-four hours.

6. That the effects of temperature upon atmospheric pressure reach their maximum in the evening, when the aerial absorption of heat from the sun ceases to be in excess of its radiation, and their minimum in the morning, when radiation ceases to be greater than absorption.

7. That the daily temperature tide increases, while the rotation tide diminishes, as we approach the poles.

8. That, in consequence of rotation, there should be a slight tendency to vertical ascending currents at 4h. and 16h., and descending currents at 10h. and 22h.

9. That whatever modifications the table may require, there can be no doubt of the existence of the three tides, with maxima and minima near the times specified, or of the possibility and desirability of accurately determining their magnitude.

2, and 3 hours from the mean tide. This would reduce the quarter-daily residual tide at St. Helena, to the following form:

1h.	2h.	3h.	4h.	5h.	6h.	7h.
−.0033	−.0029	−.0012	+.0008	+.0019	+.0019	+.0020

If this residual be added to the preceding column, it gives a result accordant with the 6th inference, except two disturbances, which, I think, can be easily explained, one at midnight, and the other in the hottest part of the day.

* James Hudson, Phil. Trans., 1832.

The phenomena on which these inferences are based, are all susceptible of a simple and obvious explanation, and thus, by reasoning alternately *à priori* and *à posteriori*, we elicit from a scheme of seemingly lawless confusion, the beauty of a most marvellous order.

Pending nominations Nos. 522, 523, 524, 525, were read, and balloted for.

Mr. Fraley, Chairman of the Finance Committee, moved that the Committee have authority to compromise the claim of the Society on the bond of Charles Wharton, secured by a mortgage on certain coal lands in Northumberland County, for a sum not less than four thousand (4000) dollars, and that, in the event of such compromise and settlement, the officers of the Society be authorized and directed to execute and deliver such instruments of writing as may be necessary to carry the compromise into effect, and affix and attest the seal of the Society thereto. The motion was passed unanimously.

On motion of Mr. Fraley, the sum of five hundred (500) dollars was appropriated to the Committee on the Hall for the purpose of meeting expenses incurred in the late repairs of the building, and moreover the sum of one hundred (100) dollars for binding books.

There being no further business before the Society, the ballot-boxes were examined by the presiding officer, and the following persons declared duly elected to membership in the Society:

Joseph Harrison, Esq., of Philadelphia.
John Foster Kirk, Esq., of Boston, Mass.
Prof. George H. Cook, M.D., of New Brunswick, N. J.

And the Society was adjourned.

Stated Meeting, August 19, 1864.

Present, seven members.

Judge SHARSWOOD, Vice-President, in the Chair.

A letter accepting membership was received from M. Morlot, dated Lausanne, 20th April, 1864.

A letter acknowledging publications was received from the Massachusetts Historical Society, Worcester, July 1st, 1864.

Letters of envoi were received from the Minister of Agriculture, &c., Paris, January 29th, and from the Light-house Board, Treasury Department, Washington, August 6th, 1864.

A letter requesting missing Proceedings was received from the Society of Antiquaries, London, July 15th, 1864.

Letters were read from Prof. Matile at the Smithsonian Institution, respecting thirty-four pieces from the archæological collection of the Society, casts of which are to be taken for general distribution.

A circular letter was received from E. Corter, Paris, June 21st, respecting the Annuaire of Count d'Hericourt.

A letter was received from Mr. Miller accepting his appointment to prepare an obituary notice of Mr. Gerhard, and one from Dr. Sparks excusing himself from his appointment to prepare an obituary notice of Mr. Quincy. On motion of Mr. Fraley, Mr. Everett was appointed in his stead.

Donations for the Library were received from M. v. Morlot, the Royal Astronomical and British Meteorological Society, the American Antiquarian and New Jersey Historical Societies, the Rensselaer Polytechnic and Franklin Institutes, Mr. Chase, Blanchard & Lea, Prof. Whitman, of Centre County, Pa., Col. Bache and the Light-house Board, the Superintendent of Public Instruction in California, and Santa Clara College, San Francisco.

Mr. James expressed his own and Mr. Lesquereux's satisfaction at the speedy publication of the first article in the XIIIth volume of the Transactions, on Californian Mosses; as its opportune distribution abroad had compelled the substi-

tution of American names, for English and German names already in the press and about to be fixed upon this interesting part of the present American Flora.

Mr. Chase stated that he looked with much interest for the confirmation of his views in regard to barometric fluctuations, from the investigations which M. Le Verrier, in his letter of June 8th, has proposed to undertake. The letter was communicated to the London Athenæum of June 25th by Admiral Fitzroy.

Mr. Lesley described, from private letters, the more recent discoveries of Prof. Desor, of Neuchâtel.

In April last, M. Desor's assistant, Mr. Benz, brought in from one of the localities of lake habitations, known as the "iron station," the first genuine human skull. M. Desor describes this skull as of a type as low as that from the Neanderthal cave, with slanting forehead and enormous circumorbital bones. Yet it undoubtedly belonged to a Helvetian, and one of large stature, for with it were obtained many Helvetian coins, lance-heads, &c., and four swords in ornamented scabbards.

In May, M. Desor carried out his long-entertained purpose of examining the Bavarian lakes, said by the German naturalists to contain no trace of *pilotis* remains; theories having been constructed to account for this curious limitation of the *pfahlbauten* to Switzerland. M. Desor visited his friend, Prof. v. Liebig, with assured confidence that all such theories were founded on a prime error of fact. In company with Mr. Benz and Prof. v. Siebold, the distinguished palæontologist of Bavaria, he visited the Lake of Starnberg, three Swiss miles from the capital, in which is an islet called the Isle of Roses, supporting the summer palace of the King. At the end of this islet, and running underneath it, *proving it to be artificial*, they found multitudes of piles, so well preserved that the rings of growth could be read; and among them quantities of antique pottery and cleft marrow-bones of five species of animals, among which were the horse, cow, stag, and hog. The excitement at Munich was very great; and the young King's government established a commission with v. Siebold at its head, who have explored already five of the Bavarian lakes, and discovered in them seven stations of lacustrine habitations, from which numerous relics of the *bronze* age also have

been dredged up, showing that it was synchronous or closely continuous with the so-called preceding Age of Stone.

Dr. Coates observed that, as he apprehended, well-known historical documents were omitted to be noticed, which yet bear upon these subjects. The transition from the brass to the iron age is indicated by Horace, and appears to have taken place, as in the migrations of the Dorians, with few if any battles. The heroes of the Iliad fight with large stones. A high state of civilization existed at the same time, as in the mention of Phoenicea, Mycenæ, and Tyre. A population being driven into a lake, and founding even a mighty city there, is exemplified by Mexico, according to the hieroglyphic records abstracted by Clavigero. Venice, also, though not situated in a lake, is a case of much analogy.

Dr. Coates reminded the Society of the general omission, as a fact in the history of the later geological age, of the narrative in Genesis of the destruction and deep depression of the cities and cultivated plain of Sodom, although preceded by the account of a great battle, with mention made of nine names of cities and eight of commanders, and connected with the account of Abraham, Lot, and Melchisedek.

Pending nomination No. 525, and new nominations Nos. 526, 527, 528, were read.

And the Society was adjourned.

Stated Meeting, September 16, 1864.

Present, eight members.

Mr. Lea, Vice-President, in the Chair.

Letters accepting membership were received from Mr. J. F. Kirk, dated Dorchester, Massachusetts, August 25th; and from Dr. Louis Stromeyer, dated Hanover, July 25th, 1864.

A letter resigning membership was received from Mr. E. E. Law, dated Philadelphia, September 10th, 1864. On motion his resignation was accepted.

A letter asking to be excused from writing another

obituary notice of Mr. Quincy was received from Mr. E. Everett, dated Boston, August 27th, 1864. On motion Mr. Everett was excused.

Photographs for the Album were received from Dr. W. S. W. Ruschenberger, Professor W. Chauvenet, Dr. L. Stromeyer, and Dr. Isaac Hays.

Letters of acknowledgment were received from the Asiatic Society of Bengal, Calcutta, October 3d, 1863; the Corporation of Harvard College, August 22d, and Captain Gilliss, Washington, August 20th, 1864.

Letters of envoi were received from the Smithsonian Institution, and Mr. J. W. Irwin, of New York City.

Donations for the Library were received from Dr. Stromeyer; the Annales des Mines; the London Society of Antiquaries; Harvard College; Silliman's Journal; the Brooklyn Mercantile Library Association; Messrs. Blanchard & Lea, and Mr. Eli K. Price, of Philadelphia.

Mr. Lea made a communication of a discussion of "Prime Right-Angled Triangles and $\surd 2$," from a private letter addressed to him from Dr. James Lewis, of Mohawk, New York.

Prime Right-Angled Triangles, and $\surd 2$.

In any R. A. Triangle, let H = hypothenuse, P = perpendicular, B = base.

Then $H^2=P^2+B^2$; whence $H^2-P^2=B^2$. H^2-P^2 is the product of two factors, H+P (=a) and H−P (=b). Accordingly,

$H^2-P^2=(H+P)\times(H-P)=ab=B^2$, and $\surd ab=B$.

$a+b=(H+P)+(H-P)\ =2\ H$ and $\frac{a+b}{2}=H$.

$a-b=(H+P)-(H-P)\ =2\ P$ and $\frac{a-b}{2}=P$.

The radical sign before ab implies that the terms a and b are squares; the fractional expressions $\frac{a+b}{2}$ and $\frac{a-b}{2}$ implies that those terms should be multiplied by 2. Substituting for the terms a and b, others that meet these indications, viz., $a=2N^2$ and $b=2S^2$, the sides of R. A. Triangles have the following general expression: $H=N^2+S^2$, $P=N^2-S^2$, $B=2NS$. If the terms N and S be any whole numbers, their expansion as indicated in the formula, will evolve the sides of Prime Right-Angled Triangles (prime, in the sense that the tri-

angles thus evolved may be analyzed without the introduction or suppression of factors). If in the above formula for prime R. A. Triangles, $x+y$ be substituted for N, and y for S, the following formula will appear: $H=x^2+2\times y+2y^2$, $P=x^2+2\times y$, $B=2\times y+2y^2$. This second formula will be chiefly referred to in the following summary:

DECOMPOSED FRACTION OF THE SQUARE ROOT OF 2.

$$\sqrt{2}=1+\cfrac{1}{2+\cfrac{1}{2+\cfrac{1}{2+\cfrac{1}{2+}}}}$$

&c. $=\frac{1}{1}=\frac{3}{2}=\frac{7}{5}=\frac{17}{12}=\frac{41}{29}=\frac{99}{70}=\frac{239}{169}$ &c. $\triangle=\frac{x}{y}=\frac{B+P}{H}$.

($\triangle$ $\triangle$ $\triangle$ $\triangle$)

$\frac{B+P}{H}=\frac{x}{y}=\sqrt{2}$ approx.

x	y
1—△—	1
3———	2
7—△—	5
17———	12
41—△—	29
99———	70
239—△—	169

The decomposed fraction of $\sqrt{2}$, when resolved into a series of numerators and denominators of common fractions $(\frac{x}{y})$ will present the values in the annexed table, column x embracing numerators, and column y the corresponding denominators. The first two terms, or INITIALS of the series, being found, succeeding terms may be found by additions, observing the following relations, $x+y=y'$, $y+y'=x'$, $x'+y'=y''$, $y'+y''=x''$, &c., continuously; or, $y+2y'=y''$, $y'+2y''=y'''$, $y''+2y'''=y''''$, &c.

In this series it will be seen that each alternate fraction ($\triangle$) embraces a triangle in the form $\frac{B+P}{H}$ in each one of which triangles is a *common characteristic*, having the expression $B-P=\pm 1$.

An analysis of the several triangles of this series, by means of the formula embracing the terms x and y, will reproduce the series of values of x and y respectively, as given in the table. This is the only series which will reproduce its radical elements, for the reason that $\sqrt{1}=1$; and the root of no other quantity than 1 is equal to itself. If the several triangles be analyzed by the formula embracing the terms N and S, N and S will successively reproduce the series of denominators y, N being in advance of S.

The general character of this and any similar series of triangles, suggests the expression "$\frac{B+P}{H}=\sqrt{2}$ approximately." Other series of triangles similarly derived from different *initials* will confirm this suggestion.

The intermediate alternate terms in the series (not distinguished by the sign △) are only approximately R. A. triangles, having the character which may be inferred from the following expression, $B^2 + P^2 = H^2 \pm 1$.

The preceding table, derived from the *initials* "1, 1," presents a series of approximate common fractions of the square root of 2, a quantity that can only be approximately expressed in limited terms. As expressions of the value of the root of 2, the successive fractions present discrepancies which have peculiar relations to $\surd 1$ or 1. Other series similarly derived from other initials, will, in a similar manner, be approximate fractions of $\surd 2$, but each series will have its characteristic discrepancy, which is related to the series as $\surd 1$ or 1 is to the series just considered. This discrepancy will appear in any series as the quantity D in the expression $B - P = \pm D$, which expression is the *characteristic* of all the R. A. *triangles* of a series.

$\frac{x}{y} = \surd 2$ approximately

x		y
1	— △ —	2
5	———	3
11	— △ —	8
27	———	19
65	— △ —	46
157	———	111
379	— △ —	268

The annexed series exhibits proportions similar to those of the preceding. The characteristics of the triangles in the alternate terms (△) in the form $\frac{B+P}{H}$, is $B - P = \pm \surd 7$. The *approximate* R. A. triangles (not designated by the sign △) may be characterized by the expression $B^2 + P^2 = H^2 \pm \surd 7$. The successive fractions $\frac{B+P}{H}$ regarded as approximations to $\surd 2$, present discrepancies which are related to $\surd 7$ or 7 as the discrepancies of the preceding table are related to $\surd 1$ or 1.

The triangles evolved by expanding the successive values of x and y, as in the formula embracing those terms, have the characteristics $B - P = \pm 7$.

This table having been derived from the initials "1, 2," by additions, may be continued backwards by subtractions, which will develop a series of terms, among which negative quantities will appear. The first pair of terms (x and y) in which a negative quantity appears, may be regarded as the *initials* of a new series, *correlative* to that from which it is derived. The *initials* being found may both be regarded as positive, and the series extended by additions, as in the preceding instances.

$x - y = y_{,}$. $y - y_{,} = x_{,,}$, $x_{,} - y' = y_{,,}$, &c. $x_{,} = +3$. $y' = -1$, the initials of the series.

$\frac{x}{y} = \sqrt{2}$ approximately

x	y
3	1
5	4
13	9
31	22
75	53
181	128

The annexed series is the *correlative* of the last preceding, and is in all respects similar, except that it is derived from different initials. Either series being given, the other may be found in the manner suggested.

In any case when a series has a *correlative*, it may be found in the same manner. In any instance in which D in the expression $B—P=\pm D$, is a prime number, or a multiple of a prime number, and the triangle to which the expression refers, is a Prime Right-Angled Triangle, as previously defined, an analysis of the triangle by the formula embracing the terms x and y, will give values for x and y, which may be extended into a series, which series has its correlative, as in the preceding instance. If D is found to embrace several factors which are prime numbers, each one of those prime factors may be found to give rise to two series of values for x and y, which will be correlative to each other, so that there will be twice as many series of values of x and y as there are prime factors in D, and accordingly twice as many series of R. A. Triangles in which $B—P=\pm D$ as there are prime factors in D.

If D is the square of a prime number, there will be three series of values for x and y, two of which will be *correlative* to each other, the initials of the third being $x=y=\sqrt{D}$.

Other generalizations might be suggested co-ordinate with these, which, however, are yet incomplete, and are reserved for further consideration.

If any prime R. A. Triangle be resolved into the fractional form $\frac{B+P}{H}\left(=\frac{x}{y}\right)$ and a series of fractions be derived therefrom by additions or subtractions, as in the preceding illustrations, the alternate corresponding values of x and y in the series will embrace a Prime R. A. Triangle in the form $\frac{B+P}{H}\left(=\frac{x}{y}\right)$, and all such triangles in the series will have the same value for D in the expression $B—P=\pm D$. If the series of values of x and y thus tabulated be expanded into a series of triangles (by means of the formula embracing x and y) the triangles thus evolved will be characterized by the expression $B—P=\pm D^2$, (D referring to its value in the former instance.)

ANY WHOLE NUMBERS WHATEVER, when used as the initials of a series under x and y, as in the preceding illustrations, will develop a series of numerators x and denominators y, of *common fractions ap-*

proximating $\surd 2$, each alternate numerator embracing B+P and its corresponding denominator H of some R. A. Triangle, in which the difference of B and P will be the square root of some whole number which will characterize the series; and the numerical value of B—P, will have the same relation to the series that $\surd 1$ has to the series derived from the initials "1, 1" in the first illustration. From the various considerations here presented, is derived the general inference $\frac{B+P}{H}=\surd 2$ approximately.

JAMES LEWIS,
Mohawk, N. Y., August 31, 1864.

Mr. Chase read a communication "On the Comparative Fitness of Languages for Musical Expression;" presenting the results of an investigation that had been suggested by the remarks of Mr. Foulke, at a previous meeting of the Society.

The fitness of any language for musical expression, depends, not on the number and character of the letters, but on the sounds that are expressed by their several combinations. I have, therefore, thought that it would be interesting to analyze the sounds, and to institute a variety of comparisons between Italian, French, English, and German, in order to determine as nearly as possible the precise nature of their harmonic differences.

In making my comparisons, I selected a number of the principal poets in each language, and examined a few passages from each. From the aggregates I framed the following Tables:

1. Number of sounds of each description in 10,000 syllables.

Sounds.	Italian.	French.	German.	English.
Vowel, . .	10,207	10,355	10,778	11,439
Nasal, . .	1,957	2,928	3,547	2,952
Liquid, . .	2,806	2,883	3,419	3,348
Sibilant, . .	1,597	2,436	2,113	2,643
Labial, . .	1,389	2,385	1,899	1,982
Dental, . .	2,532	2,132	3,626	4,266
Guttural, . .	969	863	2,341	1,351
	21,457	23,982	27,723	27,981

2. Proportion of sounds in a given number of ideas.

Sounds.	Italian.	French.	German.	English.
Vowel, . .	10,207	8,845	9,765	9,579
Nasal, . .	1,957	2,502	3,214	2,472
Liquid, . .	2,806	2,467	3,098	2,804
Sibilant, . .	1,597	2,084	1,914	2,213.
Labial, . .	1,389	2,041	1,720	1,660
Dental, . .	2,532	1,825	3,285	3,572
Guttural, . .	969	738	2,121	1,131
	21,457	20,502	25,117	23,431

3. Number of sounds of each description in 10,000 sounds.

Sounds.	Italian.	French.	German.	English.
Vowel, . .	4,757	4,312	3,888	4,088
Nasal, . .	912	1,221	1,279	1,055
Liquid, . .	1,308	1,204	1,233	1,197
Sibilant, . .	744	1,017	762	945
Labial, . .	648	996	685	708
Dental, . .	1,180	890	1,308	1,524
Guttural, . .	451	360	845	483
	10,000	10,000	10,000	10,000

It appears, therefore, that

1. In a given number of syllables, English has the greatest number of sounds, and Italian the least.

2. In the expression of a given number of ideas, German uses the greatest number of sounds, and French the least.

3. Italian is the richest in the most musical sounds, or the vowels and liquids,—German in the nasals and gutturals,—French in the sibilants and labials,—and English in the dentals.

4. In regard to the harshest and least musical sounds, German has an excess of gutturals, French of sibilants, and German of gutturals and sibilants combined.

5. German has the greatest proportion of mute, and the smallest proportion of vocal and semi-vocal sounds, and is, therefore, the least musical of the three languages.

Mr. Chase also read a communication "On Certain Primitive Names of the Supreme Being."

The resemblance between Algonquin "Manitou," Chinese mang

taou, Egyptian ma ntr, Latin magnus deus, Greek μέγας θεός, and Sanscrit maha deva, to which I made casual reference in a former communication (Trans. A. P. S., New Series, vol. xiii, p. 61), has seemed to some of my friends sufficiently interesting and important to justify a more minute and analytical exposition. The last three forms are confessedly cognate; the resemblance between the others is at least equally striking, and were it not for the wide geographical separation of the nations, and the absence of any direct evidence of intercourse, we should naturally suppose that they were derived from the same original source. But since it would be difficult to select three languages that are less likely to have sprung from a common parentage, it is reasonable to expect that the coincidence will be severely criticized by those whose prejudices forbid a belief in the unitary origin of man, and that little regard will be paid to the mathematical probability of any hypothesis that may be supposed to weaken its significance.

The Chinese corresponds precisely in meaning with the Aryan forms, but the extent of the correspondence in the Algonquin and Egyptian words, is somewhat uncertain. The probability that it is equally complete in Algonquin, is strengthened by the considerations that, 1, the Indian tribes generally speak of the Deity as the "Great Spirit;" 2, the Shyenne word for spirit is mahio; 3, the Algonquin forms mechekelo, miss, michau,—Blackfoot omuku, omaesin,—Cushna muck,—Shyenne tsimahaa,—all signify "great," and all contain the root ma, variously modified, as in C. mang, S. ma$_1$h, L. magn-, mag-, Greek μεγ-, μαχ-, E, mass, much, many, &c., &c. In Egyptian, ma ntr is properly "the true God," naa ntr being equivalent to "magnus deus." But m and n are often interchanged; the root na or naa is found in Arapoho benasa, *large*, naathia, *so large;* some of the subordinate meanings of ma are retained in Egyptian mh or mah = Ch. mang, *to fill*, and in mak = L. mag-, *to rule;* and a probable association between the ideas of truth and greatness is shown by S. uru, G. ur, L. verus, E. very, &c.

It is probable that tr and taou are both compounds, and that they may have both been originally identical in meaning, and perhaps also in form, is shown by S. tr, trai, *to conquer, to preserve, to guard;* Pawnee terahu or tidihu, *great*, terawa, *god* (Cfr. also Eg. ra, *the sun;* S. ravi, *the sun*, rādj, *to govern*, racf, *to guard*, I'svaras, *God;* Crow, isa, *large*).

The Chinese and Indian languages appear to furnish a clue to

some of the other primitive names of the Supreme Being. The root aou, *to shine* (which is in its organic formation, as well as in its significance, almost identical with r), is found nearly pure in C. haou, *appearance of the sun rising, the light of the heavens;* M. 3252–4, gaou, aou or yaou, *the light of the sun*, M. 2932; Iowa, hawe, *day;* Eg. auu, *splendor*, aui, *to glorify;* H. אור, *light;* L. aurora, Y. auro, *morning.* The same root is traceable, with some slight modifications, in C. ou or woo, *bright*, M. 11747, yaou, *very white, the splendor of the sun*, M. 11965, 11973, yuh, *the splendor of the sun*, M. 11870, heu or yu, *the air extending itself, great, warmth, sunlight, morning*, M. 3738–41, 3756–7, tsaou, *morning*, M. 10540, chaou, *the splendor of the sun, daylight*, M. 349, 1459, keaou, *white*, M. 5578, we or wei, *the light of the sun*, M. 11661, wang, *the sun going forth and shedding his illuminating beams*, M. 11620, paou, *the fierce rays of the sun;* D. wi, *the sun*, aŋpao, *dawn, daylight;* Assiniboin, aumpa, *day;* Pawnee, tewauwaupits, *lightning;* Shyenne, iwonit, *the moon rising*, iniwooniyots, *day breaking*, wowoiwo, *morning star;* Algonquin, kayshoh ("the mighty Yoh" = magnus Jov- = Shyenne mah-io), *sun, day;* S. djval, *to blaze*, dyu, *to shine*, dyaus, *the bright heaven;* Gr. ἕως, L. Eurus, C. heuh, *the light of the morning*, M. 3857.

Material existence is principally manifested through the medium of light, and accordingly we find C. we or wei, *to be*, M. 11640, yew, *existence*, M. 12107; Eg. au, *to be;* Alg. iah, iau, *to be, to do, to have;* Chaldee, yáo;* H. יה, יהוה; Ger. wesen; E. was. Prof. Max Müller has well shown the connection of deus, deva, Θεός, Ζεύς, with S. dyaus, and the resemblance of the Hebrew יהוה, ה on the one side to Alg. iah, iau, and on the other to L. Ju-, Jov-, has been pointed out by different writers, but I think no one has shown how readily all these forms may be connected through the Chinese heaou, *vapor, breath*, M. 3556, 3580; yaou, *the glory of the sun*, M. 11965; yew, *existence;* teaou, *the sovereign or watchful yaou*, M. 9992, 10004; teaou, *to look to a distance, a species of dragon*, M. 10031, 10045;† taou, *the principle from which heaven, earth, man, and all nature emanates.* According to Morrison, "Taou, in the books of Laou tsze, is very like the *Eternal Reason*,

* See Bunsen's Egypt, vol. iv, p. 193–4.

† Cfr. S. drç, Gr. δέρκω, L. draco (= "the Watcher"). The dragon is the badge of the Emperor of China, and is embroidered or painted on his standards, "in the manner of the ancient Scythians, Parthians, Persians, and Romans." The basilisk was also the emblem of the sun-god and of the monarch in Egypt.

of which some Europeans speak; *Ratio* of the Latins, and the *Logos* of the Greeks." The resemblance between Mexican Teo and Greek θεός, has been often noticed, but it has usually been dismissed as a merely accidental, though curious coincidence. In comparison with the analogues here given, it assumes a new importance.

The association of the ideas of whiteness, purity (πῦρ), brilliancy, divine glory, and sacrifice, may perhaps account for such resemblances as C. yang, *a sheep or goat, fire burning fiercely, bright, splendid, the sun, male, the superior of the two material principles into which, according to the Chinese, chaos was divided;* S. yas, *light, lustre,* adjas, *a goat,* yadj, *to sacrifice,* agni, a,gati, *fire;* L. agnus; Gr. αἶξ; Y. ake, *a goat,* agutaŋ, *a sheep,* ako (= Eg. ka), *male,* eraŋ, *a sheep* (raŋ, yaŋ, saŋ, *to shine, to burn, brilliantly*); D. saŋ, *whitish or yellowish,* agu, *to burn on or on account of anything,* wiyakpa, iyoyaŋpa, *to shine,* aŋpao, *day,* takiŋ-wanuŋ-yaŋ-pi (= "deer-accidentally-domesticated*-flock") *sheep;* Mandan, aŋsakte (= "the great aŋsa"), *mountain sheep.* The Shyennes call the sheep "the white deer."

Some of the Chinese religious expressions appear to furnish traces of the remains of an early inspiration, as well as a parallelism of thought that is indicative of a common origin. For example, by combining the two characters which represent *my* and *sheep,* the Chinese form the character for e, *good, right, suitable, righteousness.* Morrison says (under the word "light"), "The Budhists speak of a light within; thus of the principles of the Kin Kang King, they say, 'This sacred book is originally possessed by all mankind in their own nature, unperceived by themselves. When they are awakened to know their own hearts, they are assured of the internal scripture. Having the light within, they do not, like the men of the world, seek for Budh outside their own persons, nor seek for a scripture externally, but rouse the internal mind, and adhere to the internal mental scripture.' Does not this language resemble that of the Friends, called Quakers?"

Some of the latest triumphs of physical science have led to the revival of beliefs nearly identical with the intuitive or inspired perceptions of our early ancestors, as manifested in their worship of the mysterious Agency that controls the Universe. Thus we find in

* The Chinese speak of the lew chüh, the "six domestic animals," ma, *the horse* (Cfr. G. mahre, E. mare), new, *the cow* (Cfr. Sw. nöt, Dn. nöd, W. cnud, E. neat), yang, *the sheep,* ke, *the fowl* (the "caller"), keuen, *the dog* (Cfr. S. çvan, Gr. κύων), che, *the hog* (Cfr. F. cochon).

Tyndall's lectures on "Heat considered as a mode of motion" (First American Edition, p. 446, sqq.), such expressions as the following: "Every mechanical action on the earth's surface, every manifestation of power, organic and inorganic, vital and physical, is produced by the sun. . . . . He blows the trumpet, he urges the projectile, he bursts the bomb. And remember, this is not poetry, but rigid mechanical truth. He rears, as I have said, the whole vegetable world, and through it the animal; the lilies of the field are his workmanship, the verdure of the meadows, and the cattle upon a thousand hills. He forms the muscle, he urges the blood, he builds the brain. His fleetness is in the lion's foot; he springs in the panther, he soars in the eagle, he slides in the snake. He builds the forest, and hews it down; the power which raised the tree and which wields the axe being one and the same. . . . The sun digs the ore from our mines, he rolls the iron, he rivets the plates, he boils the water, he draws the train. He not only grows the cotton, but he spins the fibre and weaves the web. There is not a hammer raised, a wheel turned, or a shuttle thrown, that is not raised, and turned, and thrown by the sun." No Chinese Bonze, no Hindoo Brahmin, no Persian Fire-worshipper, no Egyptian, Grecian, or Roman priest, no Indian medicine-man, could have discoursed in more eloquent language of the power of the "Mighty Ra" or "Yau," and none perhaps, with less danger of inculcating the belief, that the mere inert material nature can exert that all-controlling power which is essentially spiritual, and can spring only from a Supreme Intelligence.

Pending nominations Nos. 525, 526, 527, 528, were read.

And the Society was adjourned.

Stated Meeting, October 7, 1864.

Present, sixteen members.

Dr. Wood, President, in the Chair.

A letter accepting membership was received from Mr. Joseph Harrison, dated Philadelphia, September 24th, 1864.

A letter acknowledging the receipt of publications was re-

ceived from the New York State Library at Albany, September 21st.

Donations for the Library were received from Professor Zantedeschi, of Padua; the London Meteorological, Geological, and Antiquarian Societies; the Essex Institute; the New York State Library; the Loyal Publishing Association; the Protestant Episcopal Convention of Pennsylvania; the Hon. William Duane and Reverdy Johnson; the Franklin Institute, and the College of Physicians of Philadelphia.

A donation for the Cabinet was received, through Mr. Chase, from Mr. W. K. Lanphear, of Cincinnati, consisting of 315 trade tokens.

The photograph of Professor J. C. Cresson was presented for the Album.

A communication offered for the Magellanic Premium, addressed to the President and signed "Torricelli," was read by Secretary Dr. Le Conte, and referred, as the By-Laws direct, to the Board of Officers.

The communication announces "the discovery of certain new relations between the solar and lunar diurnal variations of magnetic force, and of barometric pressure."

These relations may be expressed by the proportions:

$B' : B'' :: \surd A'\, M' : \surd A''\, M''$ (1)

$B' : M' :: A' : A''$ (2)

$B'' : M'' :: B' : B''$ (3)

A', A'', representing the tidal force of the sun and moon, respectively.

B', B'' the diurnal barometric variation.

M', M'', the diurnal magnetic variation.

Proportion (1) is readily deduced from (2) and (3).

Pending nominations Nos. 525, 526, 527, 528, were read.

The Committee upon the Purchase of a Site for the Hall, reported as follows:

"That they have received notice from Mr. Harrison that he has another applicant for the lot, and that he is now willing to sell. His price is $16,000, which may be in a reserved ground rent, re-

deemable after a few years, if the Society shall prefer, but he would prefer a few thousand dollars to be paid on account. We propose to offer $15,000; but consider that the Society should not miss the lot if satisfied with the location.

"The lot is the most central of any we know of, having the dimensions we require, with a front towards the southwest corner of Penn Square; and if this opportunity be lost, it is believed no vacant lot so suitable for our purpose can be had.

"The dimensions of the lot are 74 feet front, by 92 feet in depth, to a small street.

"We recommend that the Society make the purchase."

(Signed) ELI K. PRICE,
STEPHEN COLWELL,
F. FRALEY.

Dated October 3d, 1864.

To bring the matter before the meeting, Mr. Fraley moved that the Committee be authorized, at their discretion, to purchase the lot of Mr. Harrison, for a sum not greater than $16,000, and to make immediate payment of a portion, not exceeding $5,000.

After some discussion, on motion of Judge Sharswood, the consideration of the subject was postponed until the first stated meeting in November next.

And the Society was adjourned.

Stated Meeting, October 21, 1864.

Present, eight members.

Dr. BELL in the Chair.

A letter accepting membership was received from Dr. A. Tholuck, dated Halle, October 4th, 1864.

A letter of acknowledgment was received from the Chicago Historical Society, dated October 8th, 1864.

Donations for the Library were received from the Bureau of Public Instruction and Public Works, at Paris; the New England Loyal Publication Society; Messrs. Blanchard & Lea, and Bishop Stevens.

The death of Dr. William Pepper, a member of the Society, was announced by Dr. Coates. Dr. Pepper died on the 15th inst., aged 54. Dr. Coates was appointed to prepare an obituary notice of the deceased.

Mr. Chase made a communication on Terrestrial Magnetism as a Mechanical agent.

In a note to a former communication, I expressed my belief that the British Astronomer Royal would find in the mechanical action of the sun's rays, the precise "occasional currents" for which he was seeking, as the probable cause of magnetic storms. Mr. Airy has recently sent me a copy of his very interesting paper, (Trans. Roy. Soc., 1863, Art. XXIX.), and its perusal has greatly strengthened this belief.

All of my meteorological views rest upon the hypothesis, that the atmospheric changes, whether of humidity, temperature, pressure, electricity, or magnetism, are purely mechanical; and that being controlled by the laws of motion, their proper explanation does not require the assumption of any peculiar magnetic or electric fluid, but that a single homogeneous, elastic, and all-pervading æther, may be both the source and the receptacle of all the various forms of force. In its principal features, this theory harmonizes with the now generally accepted belief in the mechanical origin of light and heat, but in its details it involves some new and interesting special applications, which I have endeavored partially to develop.

It will be readily seen, by a reference to my communication of April 15, (*ante*, p. 367, sqq.), that the *mechanical* action of the currents to whose *electric* action Ampère ascribed the origin of terrestrial magnetism, produces two opposite spirals in the air and æther,—the lower moving from the poles to the equator, and against the earth's rotation; the upper from the equator to the poles, and in the same direction as the earth's rotation; the two being connected

by innumerable currents of convection, or threads of ascending and descending particles. It will also be evident that at every place there are two principal sets of such double spirals, one with an axis perpendicular to the earth's radius vector, producing a maximum disturbance in the early afternoon, and the other more stable and uniform, with an axis passing through the nearest poles of greatest cold. In addition to the mutual perturbations of these two principal polarizing currents, the rolling of the luni-tidal attraction-wave produces at every instant a greater or less derangement,* and I find that the ratio of the lunar-barometric to the lunar-magnetic disturbance (4.384), is nearly identical with Mr. Welsh's determination of the moment of magnetic inertia (4.4696; Phil. Trans., v. 153, p. 297). From a variety of considerations, it appears that the mechanical polarity or magnetic force thus engendered, is a third proportional to two other forces, which may be called, respectively, central and tangential.

The communication which was presented at our last meeting, in its exhibition of the first numerical relationship that has ever been pointed out between the barometric and magnetic fluctuations, showed that A : B : : B : M, a proportion in which A represents a central, B a tangential, and M a magnetic force.

I find a similar proportionality in each of Mr. Airy's summary tables (Op. citat., p. 627, sqq). Thus in his "Table II, Algebraic Sums of Magnetic Fluctuations (in terms of Horizontal Force) for each Year, from 1841 to 1857, including all Days of Record of Great Magnetical Disturbance," the Mean Disturbance is

Westerly Force.	Northerly Force.	Nadir Force.
—.00023=M.	—.00146=T.	—.00057=C.

Here the proportion T : C : : C : M gives for M a

Theoretical value, ...	— 000222
Observed "	—.000228
Probable error, ...	.000080

"Table III. Algebraic Sums of Magnetic Fluctuations (in terms of Horizontal Force) for each Year, from 1841 to 1857, including

* Besides the great disturbing agencies, whose effects may perhaps be determinable by mathematical prediction, every transient local accumulation of heat or cold will exert an influence. Everything that can produce currents or eddies in the atmosphere, may also be presumed to affect the æther, and the inconceivable rapidity of the æthereal motions, as manifested in the velocity of the waves of light and heat, will account for the extreme sensitiveness of the magnetic needle

only those Days of Great Magnetic Disturbance, in which Records were made by the three Instruments."

Theoretical value of M, ...	—.000287
Observed " "	—.000257
Probable error, ...	.000068

Tables V and VI, exhibit an approximation to the proportion, C : T : : T : M, but the approximation does not come within the limits of probable error. As no attention is paid in these two Tables to the positive and negative signs, we could not reasonably expect so satisfactory results as in Tables II and III.

"Table VIII. Sums, without regard of sign, of Coefficients of Magnetic Irregularity (in terms of Horizontal Force) for each Year, from 1841 to 1857, including all Days of Record of Great Magnetical Disturbance." The proportion C : T : : T : M, gives for M a

Theoretical value, ...	.001218
Observed "	.001203
Probable error, ...	.000066

"Table IX. Sums, without regard of sign, of Coefficients of Magnetic Irregularity (in terms of Horizontal Force) for each Year, from 1841 to 1857, including only those Days of Great Magnetic Disturbance, in which Records were made by the three Instruments."

Theoretical value of M, ...	.001137
Observed " "	.001150
Probable error, ...	.000081

In addition to these numerical coincidences, the following points in Mr. Airy's paper appear to me to be specially noteworthy.

1. "The Aggregate for the Westerly Force . . . . (taken in comparison with that for the Northerly Force), appears to show that on the whole, the direction of the Disturbing Force is 10° to the east of south;" p. 628. This indicates a line of mean disturbance about midway between the magnetic meridian (which, at London, is about N. 24° W.), and the solar meridian, or midway between the meridians of decussation in the two sets of principal spirals, to which I have referred.

2. "Sometimes two waves in one direction correspond nearly with one in the other direction. . . . . A more frequent relation appears to be, that the evanescence of one wave corresponds with the maximum of the other;" p. 635.

3. "The most striking particulars in the last line (of Tables VIII and IX) are the following:

"First, the almost exact equality of the Mean Coefficients of Irregularity in the three elements. . . . . With reference to their physical import, I think it likely that the equality of Coefficients of Irregularity may hereafter prove to be one of the most important of the facts of observation.*

"Second, the near agreement in the number of Irregularities for Westerly Force and for Northerly Force.

"Third, the near agreement in the number of Irregularities for Nadir Force with half the number of Irregularities for Westerly or for Northerly Force;" p. 641–2.

4. Tables X and XI (p. 643–4) show that the disturbances are greatest in the winter months and in the night hours. Table X, also appears to indicate minima of fluctuations and inequalities in months when there is the greatest uniformity of temperature, and maxima when the changes of temperature are greatest and most frequent.

5. Tables XI and XII furnish the materials for the following synopsis:

Forces.		Sums of Wave disturbance. +	Sums of Wave disturbance. −	Sums of Irregularities.	Mn Wave disturbances.	Average departure from Mean ∺	Mean Irregularity ∺	Frequency of Storms.
Westerly Force.	Time of max. . . .	20 h	10 h	10 h	20 h	13 h	15 h	9 h
	Time of min. . . .	10 h	21 h	23 h	10 h	2 h	1 h	23 h
	Amt. of max. . . .	.1170	.2191	.1976	+ .00142	.00104	.00162	126
	Amt. of min. . . .	.0165	.0083	.0346	— .00165	.00056	.00074	51
Northerly Force.	Time of max. . . .	5 h	12 h	8 h	5 h	20 h	15 h	8 h
	Time of min. . . .	22 h	1 h	23 h	22 h	1–2 h	23 h	23–1 h
	Amt. of max. . . .	.1407	.2917	.1754	+ .00038	.00168	.00144	136
	Amt. of min. . . .	.0038	.0674	.0441	— .00319	.00093	.00077	57
Nadir Force.	Time of max. . . .	7 h	14 h	10 h	0 h	3 h	0 h	10 h
	Time of min. . . .	22 h	1 h	23 h	17 h	22 h	23 h	1 h
	Amt. of max. . . .	.3976	.3133	.1241	+ .00570	.00363	.00180	86
	Amt. of min. . . .	.0355	.0306	.0177	— .00380	.00157	.00074	19

"The Soli-tidal character of the principal characteristics of the occasional Magnetic Storms, as to frequency, magnitude, inequalities wave-disturbance, and Irregularities, is seen clearly in this Table." (Table XII) p. 645. There are subordinate maxima and minima, the consideration of which will become interesting, when the laws of the principals have been well ascertained and defined.

6. "In regard to the Wave-disturbance: for Westerly Force, the aggregate is + from 17 h. to 6 h., — from 7 h. to 16 h.; for Northerly

* This approach to equality appears to be still more important, in view of the proportionality—C : T : : T : M.—P. E. C.

Force, the aggregate is + from 3 h. to 5 h., — from 6 h. to 2 h.; and for Nadir Force, the aggregate is + from 23 h. to 10 h., — from 11 h. to 22 h.;" p. 644.

7. Mr. Airy presents some conclusive considerations, "showing that the observed disturbances cannot be produced by the forces of any suddenly created galvanic current or polar magnet," and remarks as follows, respecting his theory: "The fundamental idea is, that there may be in proximity to the earth something which (to avoid unnecessary words) I shall call a Magnetic Ether; that under circumstances generally, but not always, having reference to the solar hour, and therefore, probably, depending on the sun's radiation or on its suppression, a current from N.N.W. to S.S.E., approximately, or from S.S.E. to N.N.W. (according to the boreal or austral nature of the ether), is formed in this Ether; that this current is liable to interruptions or perversions of the same kind as those which we are able to observe in currents of air and water; and that their effect is generally similar, producing eddies and whirls, of violence sometimes far exceeding that of the general current from which they are derived;" p. 646.

8. "And in the relation between E. and W. disturbances and vertical disturbances, there is a point which well deserves attention. When a water-funnel passed nearly over the observer, travelling (suppose) in a N. direction, he would first experience a strong current to the E., afterwards a strong current to the W (or *vice versa*), and between these there would be a very strong vertical pressure in one direction, not accompanied by one in the opposite direction; thus he would have half as many vertical as horizontal impulses. This state of things corresponds to the proportion which we have found throughout for the magnetic disturbances, and to the relation found in Article 18. I may also add that the rule at which we have arrived, that the waves of vertical force are few, but that their power, when they do occur, is very great, seems to correspond to what is reported of the whirlwinds of great atmospheric storms; which, violent and even frequent as they may be, occur very rarely at any assigned place;" p. 647.

I add a few considerations from Maj. Gen. Sabine's discussions. (Phil. Trans., Vol. 153, Art. XII.)

9. "The westerly deflections at Kew . . . have a decided double maximum, with an intervening interval of about eight or nine hours. . . . The conical form and single maximum which characterizes the *easterly* deflections at Kew, belong also to the easterly deflections in

all localities in North America, where the laws of the disturbances have been investigated. But . . . at Nertschinsk and Pekin . . . the conical form and single maximum characterize the *westerly* deflections, whilst the easterly have the double maximum. . . . At the two Asiatic stations, the aggregate values of the *westerly* deflections decidedly predominate, whilst in America the *easterly* deflections are no less decidedly predominant; and at Kew, . . . the amount of deflection in the two directions may be said to be balanced;" p. 282.

10. The differences of the weekly from the annual means of declination, indicate "with a very high degree of probability, an *annual variation*, whereby the north end of the magnet points more towards the east when the sun is north, and towards the west when the sun is south of the equator;" p. 291.

11. The residual errors in the monthly determinations of the Horizontal Force and of the Dip, "are thoroughly confirmatory of a semi-annual inequality, having its epochs coincident, or nearly so, with the sun's passage of the equator;" p. 303.

12. There appears to be "an increase of the Dip and of the Total Force, and a deflection of the north end of the Declination magnet towards the West, in both hemispheres, in the months from October to March, as compared with those from April to September. . . . . The greater proximity of the earth to the sun in the December compared with the June Solstice most naturally presents itself as a not improbable cause; but we are as yet too little acquainted with the mode of the sun's action on the magnetism of the earth, to enter more deeply into the question at present;" p. 307.

I have neither the leisure nor the ability to undertake an exhaustive analysis of the results thus brought together; but I present them as well worthy of a profound mathematical investigation, as confirmatory in very striking and minute particulars of my mechanical hypotheses, and as furnishing new and strong presumptive evidence of that marvellous simplicity of force to which many independent branches of modern physical research so strongly point. This evidence is strengthened by the existence, as I have shown elsewhere, of the tidal law of sines in the solar-diurnal variation of the magnetic needle, by the magnetic effect of the daily barometric rotation-tide, as exhibited in the convergence of lines of equal barometric disturbance towards the hours of high barometer and their divergence from the hours of low barometer, by many points of resemblance between the daily and yearly variation-curves, both of temperature and of magnetism, and by certain considerations confirmatory of the reason-

able presumption that there may be lunar-monthly magnetic tides, somewhat analogous to those which I have pointed out in the barometer. (Proceedings of the Roy. Soc., June 16, and Am. Phil. Soc., June 17, 1864.)

Besides the differential or tidal action of the moon, there is a slight tendency to diminish the weight of the air that is nearest the moon, and to increase the weight of that which is most remote. In proportion as this tendency is exerted in conjunction with or in opposition to that of the sun, the mean solar-diurnal magnetic currents should be increased or diminished. Slight as the disturbing influence is, and modified as it must be by various causes, both occasional and periodic (*e. g.* the earth's rotation, the cyclical revolution and consequent varying latitude of the moon at the commencement of each new month, the oscillations in the aerial rotation-spheroid produced by lunar attraction, the changes in the average temperature of day

TABLE I.

*Solar and Lunar Daily Magnetic Tides, in parts of Force.**

Solar and Lunar Hours.	Horizontal Force.		Vertical Force.		Total Force.	
	Solar.	Lunar.	Solar.	Lunar.	Solar.	Lunar.
	.00	.000	.000	.000	.000	.000
0	+1099	+006	—022	—005	+95	+005
1	+0911	—003	+229	+027	+82	—001
2	+0623	—011	+446	+031	+60	—005
3	+0368	—014	+593	+044	+40	—006
4	+0133	—020	+638	+072	+20	—007
5	—0080	—014	+608	+041	+01	—006
6	—0270	—007	+611	+050	—15	+001
7	—0394	—004	+545	+028	—26	+001
8	—0465	000	+300	—012	—36	—002
9	—0511	+022	+219	—011	—41	+018
10	—0530	+032	+074	—017	—45	+025
11	—0522	+031	—011	—037	—45	+022
12	—0481	+019	—100	—003	—43	+016
13	—0449	+017	—165	+005	—41	+015
14	—0405	+013	—224	+019	—38	+014
15	—0376	—009	—289	+048	—36	—001
16	—0352	—011	—345	+051	—35	—002
17	—0329	—008	—398	+029	—34	—003
18	—0298	—009	—465	+013	—32	—006
19	—0154	—004	—513	—011	—20	—005
20	+0130	+003	—582	—053	+03	—005
21	+0470	+006	—491	—050	+34	—002
22	+0803	+013	—427	—054	+63	+004
23	+1019	+009	—214	—067	+85	—001

* The first decimal figures are placed, for convenience, in an upper line.

and night at different seasons and in different years, &c.), it may yet, perhaps, be discernible in comparing the results of a long series of careful and delicate observations. The accompanying tables are deduced from such a comparison of the St. Helena records.

Table I is compiled from Maj. Gen. Sabine's Tables 36, 37, 50, 51, 52, 53 (St. Helena Observations, Vol. II). It is specially interesting as showing the influence of the opposition of attraction to rotation in producing low solar tides at 10 or 11 P. M., the prompt and direct influence of the sun upon the æthereal currents in the production of a high tide at noon, the double maxima and minima in each of the lunar tides, the additional confirmation of the analogies that I have heretofore pointed out between the spheroids of attraction and rotation, the opposition of the solar and the resemblance of

TABLE II.

Lunar-Monthly Magnetic Tide of Horizontal Force.

Moon's Position. ☽	Mean Daily Fluctuations of Horizontal Force at St. Helena.*			
	1844.	1845.	1846.	1844-6. Average.
0	61.31	53.75	40.88	51.98
15	61.66	53.29	41.24	52.06
30	62 20	52.85	41.73	52.26
45	62.32	53.61	41.81	52.58
60	62.56	52.40	40.66	51.87
75	62.76	52 36	41.34	52.15
90	61.82	52.80	41.54	52.05
105	61.37	53.11	40.42	51.63
120	60.47	53.43	39.97	51.29
135	59.42	53.60	40.46	51.16
150	60 23	53.01	40 14	51.13
165	60.54	53.46	39.72	51.24
180	58.81	53.91	40.86	51.19
195	59.39	53.64	40.27	51.10
210	59.35	53.57	40.70	51.20
225	58.88	52.91	40.74	50.85
240	59.66	52 80	39.79	50.75
255	60.35	52.92	40.70	51.32
270	60.50	53.43	40.65	51.51
285	60.89	53 81	41.10	51.94
300	61.64	52.82	41.41	51.96
315	61.80	53.10	41.34	52 08
330	62.14	53.45	42 39	52.66
345	62.16	52.97	41.85	52.32

* The value of one scale division is .00019 of the Horizontal Force, in 1844 and 1845, and .00021 in 1846.

the lunar zenith and nadir effects, and the evidence in the partial "establishment" of the moon's tides that most of her magnetic influence is exerted indirectly on the æther, through the intervention of atmospheric attraction-currents.

Tables II and III were formed by taking the mean of the hourly averages, on the twenty-four days in each lunar month which are most nearly indicated by the angular positions given in the first column. Each of the tabular numbers for 1844 and 1845 represents the average of two hundred and eighty-eight hourly observations; each of the numbers for 1846, the average of two hundred and sixty-four observations, with a few exceptions of holidays and other omitted days, for which the missing numbers were interpolated. Table II indicates a tendency to mean lunar influence between 90° and

TABLE III.

Lunar-Monthly Magnetic Tide of Vertical Force.

Moon's Position. ☌	Mean Daily Fluctuations of Vertical Force at St. Helena.*			
	1844.	1845.	1846.	1844–6. Average.
0	48.42	48.51	43.56	46.83
15	48.21	48.55	43.90	46.89
30	47.33	48.53	44.55	46.80
45	47.33	48.25	43.96	46.51
60	47.45	48.47	43.69	46.54
75	47.62	47.88	44.22	46.57
90	47.65	47.43	44.77	46.62
105	47.62	46.92	45.31	46.62
120	47.53	47.42	45.65	46.87
135	47.76	47.40	47.30	47.49
150	47.55	47.50	47.23	47.43
165	47.52	47.70	47.02	47.41
180	47.06	47.77	46.54	47.12
195	47.96	48.02	46.29	47.42
210	48.14	48.26	45.88	47.43
225	47.49	48.26	46.39	47.38
240	48.40	48.60	45.32	47.44
255	48.16	48.52	44.64	47.11
270	48.00	48.08	44.54	46.87
285	47.93	47.70	44.61	46.75
300	48.06	48.26	44.91	47.08
315	48.17	48.56	44.95	47.23
330	48.49	47.91	43.78	46.73
345	48.18	47.44	43.99	46.54

* The value of one scale division varies from .00051 to .00091 of the Vertical Force.

105°, and between 270° and 285°, the influence increasing when the moon acts either in conjunction with the sun, or directly upon condensed air and *vice versâ*. It also shows the existence of disturbances, which may be accounted for by some of the causes to which I have already referred. Table III exhibits apparent tendencies to diminution of force near the syzygies, and to increase of force a day or two after the quadratures.

Table IV is a compendium of the tidal differences in the two preceding tables. It shows the effect of temperature in producing maxima and minima when the coolest and warmest portions of the earth are submitted to the direct action of the moon (at or near 240° and 45°), low temperature producing a minimum of horizontal force, with a maximum of vertical force, and *vice versâ*. From the variations of horizontal force $\left(\frac{\triangle X}{X}\right)$ and vertical force $\left(\frac{\triangle Y}{Y}\right)$ given in this table, Table V is formed, the mean variations of total force $\left(\frac{\triangle \varphi}{\varphi}\right)$ being

TABLE IV.

Lunar-Monthly Magnetic Tide. Differences from Monthly Means.

Moon's Position. ☽	Horizontal Force.			Vertical Force.			Means.	
	1844.	1845.	1846.	1844.	1845.	1846.	H. F.	V. F.
0	+ .38	+.54	— .02	+.59	+ .51	—1.56	+.30	—.16
15	+ .73	+.08	+ .34	+.38	+ .55	—1.22	+.38	—.10
30	+1.27	—.36	+ .83	—.50	+ .53	— .57	+.58	—.19
45	+1.39	+.40	+ .91	—.50	+ .25	—1.16	+.90	—.48
60	+1.63	—.81	— .24	—.38	+ .47	—1.43	+.19	—.45
75	+1.83	—.85	+ .44	—.21	— .12	— .90	+.47	—.42
90	+ .89	—.41	+ .64	—.18	— .57	— .35	+.37	—.37
105	+ .44	—.10	— .48	—.21	—1.08	+ .19	—.05	—.37
120	— .46	+.22	— .93	—.30	— .58	+ .53	—.39	—.12
135	—1.51	+.39	— .44	—.07	— .60	+2.18	—.52	+.50
150	— .70	—.20	— .76	—.28	— .50	+2.11	— 55	+.44
165	— .39	+.25	—1.18	—.31	— .30	+1.90	—.44	+.42
180	—2.12	+.70	— .04	—.77	— .23	+1.42	—.49	+.13
195	—1.54	+.43	— .63	+.13	+ .02	+1.17	—.58	+.43
210	—1.58	+.36	— .20	+.31	+ .26	+ .76	—.48	+.44
225	—2.05	—.30	— .16	—.34	+ .26	+1.27	—.83	+.39
240	—1.27	—.41	—1.11	+.57	+ .60	+ .20	—.93	+.45
255	— .58	—.29	— .20	+.33	+ .52	— .48	—.36	+.12
270	— .43	+.22	— .25	+.17	+ .08	— .58	—.17	—.12
285	— .04	+.60	+ .20	+.10	— .30	— .51	+.26	—.24
300	+ .71	—.39	+ .51	+.23	+ .26	— .21	+.28	+.09
315	+ .87	—.11	+ .44	+.34	+ .56	— .17	+.40	+.24
330	+1.21	+.24	+1.49	+.66	— .09	—1.34	+.98	—.26
345	+1.23	—.24	+ .95	+.35	— .56	—1.13	+.64	—.45

obtained by the formula $\frac{\triangle \varphi}{\varphi} = \cos^2 \theta \frac{\triangle X}{X} + \sin^2 \theta \frac{\triangle Y}{Y}$. I have taken $\theta = -22°$; one scale division of horizontal force = .000194; one division of vertical force = .000792; which are almost identical with the values employed by Gen. Sabine in the computation of his Tables of hourly variation in solar and lunar total force.

In a similar manner I have computed Table VI, showing the average hourly variations, both in solar and lunar total force, in each of the three years which have furnished the data for most of my deductions. The first decimal figures are placed in an upper line, as in Table I. Perhaps the principal utility of this table may be found in some future extension of these investigations, but even now it is interesting, inasmuch as it exhibits the probable influence of periodic causes in shifting the hours of the daily maxima and minima, and as it lends added weight to the preceding tables, by showing that the monthly tide is more regular than the daily tide.

TABLE V.

Lunar-Monthly Magnetic Tide of Total Force.

Moon's Position. ☌	Mean Daily Fluctuations at St. Helena, in parts of Total Force.			
	1844.	1845.	1846.	1844–46. Average.
0	+.00013	+.00015	—.00018	+.00003
15	+.00017	+.00007	—.00008	+.00005
30	+.00016	.00000	+.00007	+.00008
45	+.00018	+.00009	+.00002	+.00010
60	+.00023	—.00008	—.00020	—.00002
75	+.00028	—.00015	—.00003	+.00003
90	+.00013	—.00013	+.00007	+.00002
105	+.00005	—.00014	—.00006	—.00005
120	—.00011	—.00003	—.00010	—.00008
135	—.00026	.00000	+.00017	—.00003
150	—.00015	—.00009	+.00011	—.00004
165	—.00010	+.00001	+.00001	—.00003
180	—.00044	+.00009	+.00015	—.00007
195	—.00024	+.00007	+.00003	—.00005
210	—.00023	+.00009	+.00005	—.00003
225	—.00038	—.00002	+.00012	—.00009
240	—.00015	.00000	—.00016	—.00010
255	—.00006	+.00001	—.00009	—.00005
270	—.00005	+.00005	—.00011	—.00004
285	.00000	+.00007	—.00002	+.00002
300	+.00014	—.00004	+.00006	+.00006
315	+.00018	+.00004	+.00005	+.00009
330	+.00027	+.00003	+.00010	+.00013
345	+.00024	—.00010	+.00003	+.00006

It seems not improbable that the mutual planetary perturbations which are sufficiently powerful to affect their orbital revolution, may also exert an appreciable influence on their æthereal spheroids, and that numerous cyclical magnetic variations may be thus produced. The disturbance of Jupiter is by far more important than that of any other planet, its mean attractive energy being nearly a third proportional to those of the sun and moon.* The annual fluctuations are very great, the intensity being about $\frac{1}{1\,1\,4}$ when Jupiter is nearest the earth, and less than half as great, or only about $\frac{1}{2\,4\,7}$, when most remote. The combined operation of the tropical revolutions of Jupiter, the moon's apsides, and the moon's nodes, should produce a series of disturbances corresponding very nearly in duration with

TABLE VI.

Solar and Lunar-Daily Tides of Total Force.

Solar and Lunar Hours	1844.		1845.		1846.	
	Solar.	Lunar.	Solar.	Lunar.	Solar.	Lunar.
	.000.	.000.	.000.	.000.	.00.	.000.
0	+83	+009	+88	—009	+066	+004
1	+83	+011	+97	—014	+104	+015
2	+67	—005	+85	—016	+097	—004
3	+49	—004	+63	—008	+076	+018
4	+28	—024	+41	—012	+054	+017
5	+15	—032	+20	—001	+031	+024
6	+02	—027	+02	+002	+008	+028
7	—11	—016	—11	+010	—014	+022
8	—22	—006	—24	+003	—026	+022
9	—31	+001	—35	+034	—036	+022
10	—35	+008	—39	+041	—043	+024
11	—37	+029	—46	+031	—047	+021
12	—37	+017	—48	+021	—053	+008
13	—38	+021	—43	+012	—048	+011
14	—39	+045	—44	+012	—040	—001
15	—32	+021	—42	+006	—038	—029
16	—30	+001	—39	+006	—043	—033
17	—29	—004	—39	+006	—041	—027
18	—22	—012	—37	—008	—042	—020
19	—24	—006	—36	—016	—041	—019
20	—16	—014	—24	—008	—027	—011
21	+07	+017	+03	—006	—008	—021
22	+38	+022	+32	—002	+029	—008
23	+64	+016	+63	—008	+063	—010

* If we take as our unit the moon's attraction for the earth $\frac{M}{D^2}$, he sun's will be about 177, and Jupiter's $\frac{1}{1\,7\,4}$.

Gen. Sabine's magnetic "decennial period," and Schwabe's period of solar spots.

The law of varying attraction suggests a plausible explanation for the approximate mean proportionality of the barometric to the tidal and magnetic variations. For the ratios of attraction of any planet when in solar conjunction, at quadrature, and in opposition, vary as $(n+1)^2$, n^2, and $(n-1)^2$, respectively, the attraction at the mean distance being nearly a mean proportional between the maximum and minimum attractions. The barometrical fluctuations are occasioned by variations in the gravitation of the air towards the earth's centre,—the tidal motions, by the influence of distant heavenly bodies,—and the magnetic, according to my hypothesis, by the oscillations of the air and æther in their efforts to restore the unsettled equilibrium. The three disturbances, therefore, must evidently have nearly the same mutual relations as if they were produced by three forces, one centripetal, and the other two centrifugal, the two latter being nearly equal in amount but diametrically opposed in direction. This leads us at once, theoretically, to the general formula with which we started empirically,

$$A : B :: B : M,$$

and strengthens the conviction that there are none of the phenomena of terrestrial magnetism which cannot be explained, either by the instantaneously received and instantaneously transmitted impressions which are made directly upon the æther by attraction, heat, or rotation,—by the more sluggish oscillations of the air, which originate from the same sources,—or by the combination of the two.

Every particle is exposed to the influence of these several impressions, the tidal waves of the solid earth having a range, according to Prof. Thomson's calculations (Phil. Trans., Vol. 153, p. 574), at least two-fifths as great as if the globe were entirely fluid. There is, therefore, good reason to hope, that by the application of mechanical laws to the several phases of the æthereal undulations which produce the phenomena of light, heat, electricity, polarity, aggregation, and diffusion, we may obtain a clearer understanding, not only of all the meteorological changes, but also of seismic tremors, crystallization,* stratification, chemical action, and general morphology.

* The phosphorescence that is often observed during the process of crystallization, and the auroral displays in frosty air, are perhaps owing to analogous vibrations. Every chemical, as well as every physical action produces a ponderable disturbance of equilibrium, which must give rise to æthereal oscillations, to which, in their simplest form, we give the name of electric, magnetic, or galvanic currents.

If density is a functional product of superficial magnetism and central attraction, the resemblance of the formula $B = \sqrt{AM}$, to the expression of Mr. Graham's experimental law of molecular diffusion, Time $= F \sqrt{\text{Density}}$ (Proc. Roy. Soc. No. 56, p. 616–7), and to the general theoretical formula of which Mr. Graham's is a corollary,

$$\text{Velocity} = F \sqrt{\frac{\text{Elasticity}}{\text{Density.}}}$$

may be something more than accidental.

If we assume the atmospheric density as our unit, $D' = 1$, and represent the aerial and æthereal elasticities by E', E'', respectively, the proportion

$$\tfrac{1}{5} : 192{,}000 :: \sqrt{\frac{E'}{D'}} : \sqrt{\frac{E''}{D''}}$$

gives an approximate value for the density of the kinetic æther, $D'' = .00000000000108 \frac{E'}{E''}$. The magnetic and barometric fluctuations may perhaps furnish the necessary data for determining the unknown ratio $\frac{E'}{E''}$.

Mr. Marsh exhibited a Manuscript Chart, and read a letter from Mr. R. P. Gregg, of Manchester, England, in reference to the recent observations of Messrs. Gregg and Herschel, upon the radiant points of Star Showers.

Pending nominations Nos. 525, 526, 527, 528, were read and balloted for.

On motion of the Librarian, with the approval of the Committee on the Library, the sum of seventy dollars and ten cents ($70 10), was appropriated to pay Messrs. Pawson and Nicholson's bill of 14th inst., for the binding of books.

There being no other business, the ballot boxes were examined by the presiding officer, and the following persons were declared duly elected members of the Society:

Rev. Prof. T. C. Porter, of Lancaster, Pa.
Rev. John Bost, of Laforce, near Bergerac, France.
Rev. Prof. C. P. Krauth, of Philadelphia.
Mr. R. H. Lamborn, of Altoona, Blair County, Pa.

And the Society was adjourned.

Stated Meeting, November 4, 1864.

Present, twenty-two members.

Professor CRESSON, Vice-President, in the Chair.

Letters accepting membership were received from Prof. Tunner, dated Leoben, October 6th, and Dr. Schinz, dated Strasburg, October 9th, 1864.

Letters of acknowledgment were received from the Geological Institute, dated Vienna, September 19th, 1862; the Royal Society, dated London, May 16th; and the Linnean Society, dated August 8th, 1864.

Letters of envoi were received from the Imperial Academy, dated Vienna, June 23d; the Royal Academy, dated Berlin, February 29th; and the Royal Academy, dated Madrid, April 20th, 1864.

Photographs for the Album were received from Mr. Peter W. Sheafer, Prof. Tunner, and Dr. Schinz.

Donations for the Library were received from the Societies and Academies at Königsberg, Berlin, Vienna, St. Gallen, Frankfort on Maine, Bonn, Haarlem, and Madrid; the Institut de France; the Royal, Royal Geographical, Chemical, Zoological, and Linnean Societies, at London; the Royal Dublin Society; Mr. Safford, of Cambridge; Mr. Whitmore, of Salem; Rev. E. C. Jones, of Blockley; Mr. Evans, of Philadelphia, and the Franklin Institute.

The death of Admiral Sir John Washington, a member of this Society, at Havre, in the sixty-third year of his age, was announced by the Secretary, who read an Obituary Notice of the deceased from the last anniversary address of the President of the Royal Geographical Society.

The Secretary presented a communication intended for the Transactions, by Prof. Jacob Ennis, entitled "The Nebular

Hypothesis;" it was referred to a committee, consisting of Prof. Kendall, Mr. Chase, and Mr. Marsh.

The stated business being called for, the report of the Special Committee on the Purchase of a Site for a new Hall was read from the minutes of October 7th. Mr. Fraley was requested to make a statement of the financial condition of the Society, which he did, and after debate by the members, the resolution of October 7th was again read, and, on the question being put to the meeting, it was not adopted.

On motion of Mr. Fraley, and at the suggestion of the Treasurer, the sum of one hundred and fifty dollars additional, was appropriated to the general account of the current year.

And the Society was adjourned.

Stated Meeting, November 18, 1864.

Present, twelve members.

Dr. Wood, President, in the Chair.

Letters accepting membership were read, from Prof. T. C. Porter, dated Lancaster, November 11th, and from Prof. Bernard Studer, dated Berne, October 30th, 1864.

Donations for the Library were received from the British Association for the Advancement of Science; the Royal Astronomical Society; Prof. Treadwell, of Cambridge, Mass.; Silliman's Journal; Dr. Tafel, and Blanchard & Lea, of Philadelphia.

Dr. Goodwin read an obituary notice of Dr. Hitchcock.

OBITUARY NOTICE OF THE REV. PROF. EDWARD HITCHCOCK, D.D., LL.D.

THIS distinguished member of the American Philosophical Society died near the close of last February. The following leading facts of his life, presented as dry chronological data, together with a general estimate of his character and labors, are chiefly drawn from a funeral discourse by Professor Tyler.

"Dr. Hitchcock was born at Deerfield, Massachusetts, in 1793; was principal of the academy in his native place from 1815 to 1818; entered the Congregational ministry in 1821, and continued the pastor of a church until 1825, when he was elected Professor of Chemistry and Natural History in Amherst College; he was appointed State Geologist of Massachusetts in 1830, and of the first district of New York in 1836; was chosen President of Amherst College and Professor of Natural Theology and Geology in 1844; was appointed Commissioner of Massachusetts, to examine the Agricultural Schools of Europe in 1850; retired from the Presidency of Amherst College in 1854; was appointed to complete the Geological Survey of Vermont in 1857; and continued to lecture in his Professorship of Natural Theology and Geology till the time of his death."

Besides his membership in our Society, "his elections to membership in literary and scientific associations in his own country and in foreign lands, and his invitations to other fields and departments of labor which he did not feel at liberty to accept, were too numerous to be mentioned."

"It is curious enough, that his first publication was a poem of five hundred lines, which appeared in 1815, on 'The Downfall of Bonaparte.' It drew attention to the youthful author, and also procured him some substantial benefits. His next appearance before the public was in quite another capacity, that of a mathematician and astronomer. The American republisher of the English Nautical Almanac offered ten dollars to any man who should discover an error. The young savant of Deerfield, then Principal of Deerfield Academy, sent him a list of forty-seven errors, and, on receiving only evasive answers, published the list. This drew forth a contemptuous reply, in which the critic who has presumed to arraign the editor of the Nautical Almanac, is spoken of as 'one Edward Hitchcock.' The calculations for the next year were revised with great care, but no sooner had the almanac appeared than that same Edward Hitchcock

dared to send out after it a list of errors more numerous than that of the previous year. And so the controversy went on, till the editor, discovering his mistake, changed his tone, and one Edward Hitchcock became first Mr. Edward Hitchcock, and at length due acknowledgment was made in the preface, of the editor's obligations to 'Edward Hitchcock, Esq., to whom much credit is due for the industry and talent bestowed on the work.' During the four years of his connection with Deerfield Academy, he went through every year all the calculations for the Farmer's Almanac, not excepting those for the weather, to which his imagination was as competent as his science was to calculate the eclipses and conjunctions."

"While in charge of his parish at Conway, he found exercise and recreation in making a scientific survey of the western counties of Massachusetts. This was the beginning of that life among the rocks and mountains, which was ever after a delight and almost a passion. Like the giant in classical mythology, whenever he could plant his feet on the bosom of his mother earth, he was in his element; it was his strength, his health, his life. This was also the origin of the geological survey of the entire State, which was afterwards made by the Government at his suggestion, and which has the honor of originating that rapid succession of scientific surveys in the several States, which has since done so much to develop the mineral and agricultural resources of our country."

"Thus the way was prepared for his appointment as the first Professor in the chair of Chemistry and Natural History in Amherst College. When he entered upon the duties of his office, the College was yet in its infancy. The chemical apparatus was then not worth ten dollars. Cabinet there was none. Not even a beginning had been made of those magnificent scientific collections which now adorn the College halls. For many years he was sole professor in all the departments of Natural History. He lectured and instructed in Chemistry, Botany, Mineralogy, Geology, Zoology, Anatomy and Physiology, Natural Theology, and sometimes—to fill a temporary vacancy—he was the most suitable person the College could depute to teach also Natural Philosophy and Astronomy. Like Solomon, he spake of trees, from the cedar tree that is in Lebanon to the hyssop that groweth out of the wall; he spake also of beasts, and of fowl, and of creeping things, and of fishes. He spake also of rocks and soils, of which, so far as appears, Solomon did *not* speak. He dealt also in songs and proverbs, to say nothing of playing the Ecclesiastes in making sermons. He lived to see the departments of his original

professorship occupy, in whole or in part, the time of four men; the chemical laboratory and apparatus among the finest in the United States, and the scientific collections filling two spacious edifices; and all this the fruit, directly or indirectly, of his own enterprise, energy, and perseverance. Dr. Hitchcock created the *material* and the reputation of Amherst College in the Department of Natural History."

"He had the originality and creative power which belong to genius. He was made for a discoverer, for an originator of new ideas, new theories, new methods, new measures. He was tall enough to see over the heads of those around him, and catch the first dawning beams of a new day. He had more faith than most men in new discoveries. This believing disposition sometimes amounted to credulity, and welcomed a premature announcement, or a fabrication even, like the celebrated moon hoax; but it expected great things, attempted great things, and achieved great things, for science. It wrought miracles in the scientific world. He saw an element of truth in Phrenology, recognized some unknown and mysterious power in Animal Magnetism, or Mesmerism, as he more frequently called it; and in the true spirit of a philosopher, sought to extricate the truth and discover the power. As a Christian philosopher he welcomed every discovery in Geology and the physical sciences, never doubting that they would not only harmonize with, but illustrate and confirm, the Sacred Scriptures. Ichnology, as a science, began, and as yet may almost be said to end, with him. He was the originator of the State Scientific Surveys. The American Scientific Association is said to have sprung from his suggestion; and he was its first President. He possessed in a remarkable degree that power of rapid and wide generalization, by which the fall of an apple suggested to Newton the law of universal gravitation. Taught by a few terraces on the hillsides, he could reconstruct the Connecticut Valley at each successive geological epoch of its existence; and guided by a few footmarks in the sandstone, he could repeople it with its various orders and tribes of primeval inhabitants. If he had not been a great geologist and naturalist, he would have been a great astronomer and mathematician. The question which he should be, turned, not on the faculties with which he was endowed, but on the accident, or rather the providence, of his impaired health and eyesight."

"In addition to the engrossing labors of a professorship combining several distinct departments, or of the presidency, combined with a professorship quite sufficient of itself to employ one man, and besides

the innumerable special plans and efforts to raise funds, build cabinets, and make scientific collections, he has published to the world more than twenty books, of all sizes, from small duodecimos to large quartos, besides innumerable articles in the daily, weekly, and quarterly literary, scientific, or theological journals, amounting in all to eight thousand pages. Several of these books, besides numerous editions in this country, have been republished in Europe, and won for him a world-wide reputation."—(Thus far chiefly in the words of Prof. Tyler.)

But after all, Dr. Hitchcock was not so much a great genius, or a great savant, as a great and good man.

There are two characteristic and salient traits in his scientific history, to which it may not be amiss to draw special attention. The first is, that, like Newton, he always held science and religion together, not in antagonism, but in co-ordination and harmony. The second is, that, like Franklin, he combined his scientific pursuits with a steady and zealous devotion to the duties and utilities of practical life.

However engrossed by his favorite geological studies, he was still a Christian believer; and there was no subject of investigation of greater interest with him than to trace out the harmony between faith and reason, between nature and revelation, between the discoveries of science and the disclosures of the Bible. In this he differed from many scientific men of the present time; and thus, perhaps, he even lost caste in the view of some, and came to be regarded as weak or narrow-minded, or deficient in scientific force and freedom. Had he ignored or even assailed the Bible, his scientific reputation, his character as an independent thinker, inquirer, and discoverer, might perhaps have stood higher than they now do. Besides those who think that modern discoveries and the "positive philosophy," have at length demolished the Bible, there are many more who think that, at least, science has nothing at all to do with the Bible, either for it or against it.

Here we find two extreme parties. On the one hand, too many religious men and religious teachers are in the habit of denying and anathematizing science, or treating it with vituperation and scorn, as if it were the natural enemy of Christianity, the fountain of error and infidelity, of impiety and atheism. And on the other hand, scientific men have by no means been wanting, who have been ready, on every occasion, to make a thrust at the Christian Scriptures, showing up their alleged blunders and scientific ineptitudes; or, ignoring their

existence altogether, coolly to take their falsehood for granted, and pass by their testimony in silence, while propounding theories and doctrines in palpable antagonism with their received and accredited teaching.

With neither of these parties did Dr. Hitchcock have any sympathies; and in this he showed the truest scientific as well as religious instinct. For not only is anti-scientific bigotry suicidal for the religious teacher, but anti-christian bigotry is equally so for the scientific inquirer.

Is it true that Science is simply to mind her own business and let the Bible take care of itself? This is, perhaps, the prevailing tone of the scientific world. But is such a view philosophical? Is such a position tenable—*scientifically* tenable? So far as Science restricts herself to the discovery, the orderly digesting, and historical statement of *facts*, it is all well. She need not trouble herself about the Bible; just as she need not trouble herself about ethics or mathematics. But the moment she proceeds to enunciate a theory, to draw inferences from her facts, to dogmatize, she is not at liberty coolly to announce as verities or even as probabilities, doctrines which stand in flagrant contradiction to other facts and other truths resting upon appropriate and commonly received evidence,—and that, too, without attempting to refute, or even so much as alluding to, those other alleged facts and truths, or to the evidence on which they repose. Such a procedure cannot claim to be either philosophical or scientific. Science must aim at a harmony of truth, at a unity of conception. No truth, no evidence lies beyond her sphere. If she reject any facts, if she neglect any testimony, she undermines the very foundations of her whole edifice. It is not narrow-mindedness but large-mindedness, which leads a true philosopher to take into his account all the facts and all the evidence from all sources and of every kind, before drawing his definitive conclusion.

It seems to be too often forgotten that there is *real evidence* for the truth of the Christian religion, and for the Divine authority of the Holy Scriptures, and consequently for the truth of whatever they teach,—evidence of facts and testimony,—evidence, taken as a whole, of vastly greater compass and weight than there is for any scientific dogma whatever, which stands in contradiction to the Bible or any of its contents,—evidence which cannot be annihilated or rebutted by being simply ignored,—evidence which, until it is fairly and directly met and refuted, stands firm, and will stand firm forever.—(*Vid.* Rev. of Lyell's Antiquity of Man, in the Am. Theol. and Presb. Quart. Rev., April, 1864.)

Dr. Hitchcock did not pursue his studies as a man of scientific leisure. He did more than one man's work as a Professor and College President. He was the head and heart and soul of Amherst College,—its real father and founder. He made it and left it what it is. Nor did the College absorb all his practical energies. He took a deep interest and an active part in the cause of popular education, and particularly of female education. Sympathy for the masses conspired with his zeal for the promotion of Christian culture to interest him deeply in all the early plans and efforts for the establishment of the celebrated Mount Holyoke Seminary. "All the principles and methods in which it should be founded and conducted were discussed with him and other friends of learning and religion at his house; and when, at length, they were sufficiently matured, his tongue and his pen were among the chief organs for communicating them to the public. And from that time to the day of his death, next to Amherst College, Mount Holyoke Seminary was the child of his affections and the object of his constant watch and care."

In active efforts also for the suppression of intemperance, he took a zealous and prominent share. And, whatever may be thought of the special plans or processes of some of the friends of the so-called Temperance movement, surely no one can witness the multiform evils and mighty woes brought upon the community by the intemperate use of intoxicating drinks, and wonder that a man of moral principle and Christian character, of humane instincts and almost feminine sensibility, should have had his spirit stirred within him to seek some remedy, to put forth some effort, for the removal of such a prolific source of evil, for the eradication of such a loathsome and deadly cancer from the bosom of society.

Amidst all his studies and avocations, Dr. Hitchcock never forgot his relation to the Church of Christ and his character as a Christian minister. He was punctual, diligent and zealous in the discharge of every religious duty.

Nor did he forget his obligations to his country. He was a stern patriot, a loyal man, and a good citizen.

He was a Christian; but his type of a Christian was not a monk; he was religious, but not what the French call *un religieux;* he was devout, but not a *dévôt.*

He was a Christain minister; but his ideal of a Christian minister was neither the mere functional priest, nor the mere professional preacher, nor both combined. In becoming a Christian and a clergyman he had not ceased to be a man, and to be interested in whatever

is addressed to human intelligence and human sympathy by the God of Nature and of Providence, and by the actual condition, the wants and the welfare, and the manifold activities and relations of mankind.

He was a scientific man, but not that alone. In recognizing the relations of his intellect to nature, he did not allow himself to become so absorbed in them as to forget the higher relations of mind and heart to God, and the broader and the closer relations of both to society.

In the imminent danger of his country, he was no mere ingenious Archimedes. He never would have met an irruption of hostile and triumphant soldiery into his house with a "*nolite turbare circulos meos.*" He was no literary recluse. He had no affinity of character with such a man as Joseph Scaliger. He could not have been so engrossed in the study of Homer as not to have been aware of such a scene as the massacre of St. Bartholomew's eve, or of his own hair-breadth escape from the common butchery, until the day subsequent to the catastrophe.

He observed, he studied, he thought, he felt, he acted; but he was no mere observer, no mere student, no mere thinker, no mere sentimentalist, no mere agitator or drudge, no mere fragment of humanity, however sharp, or polished, or brilliant. He was a whole-souled, large-minded, living man, recognizing his practical relations to man and God, as well as his intellectual relations to nature and truth. His highest ambition and most fervent prayer undoubtedly were, to be a true man and an earnest Christian, rather than a *savan* or a philosopher, to have his name written among the wise who shall shine as the brightness of the firmament, rather than emblazoned on the records of human science and learning. To him, as to Solomon, God gave more than he asked.

PHILADELPHIA, November 18, 1864.

The death of Dr. Heinrich Rose was announced by the Secretary, as having taken place at Berlin on the 27th of January last, at the age of sixty-eight years and five months.

The minutes of the last Stated Meeting of the Board of Officers and Council were read.

And the Society was adjourned.

Dr. Harris exhibited specimens of *Crude Borax* or *Tincal*, and *Refined Borax*, obtained from the lake country of California, about 130 miles north of San Francisco, where it is deposited in the form of small crystals, and large crystalline masses, varying from a few grains to half a pound in weight, at the bottom of several small lakes, the waters of which are saturated with this salt. The most important of these lakes is situated in the vicinity of "Clear Lake," and covers about 200 acres of land.

The existence of this mineral in California has been known for several years, but the greater inducements offered by gold mining, have occasioned it to be neglected until recently, when a Company was formed for the purpose of collecting and refining it. This corporation owns about 2200 acres of land, embracing the borax lakes, a boiling spring of boracic acid, and an immense deposit of sulphur, of a remarkable degree of purity.

The crude borax of California is remarkably fine, being crystallized in hexagonal prisms, of a slightly greenish hue, translucent, and effloresces slowly. It is entirely free from any soapy or greasy feel, which is common to the crude borax of India, and is said to contain but about ten per cent. of impurities. The "refined borax," is not entirely pure, and not being prepared as it should be, contains too large a proportion of water of crystallization, the loss of which causes a considerable efflorescence to appear on the surface.

The Company raise the crude borax with a dredging machine, wash it free from mud, and then refine it. They intend, also, to evaporate the water of crystallization by artificial heat, and to combine the boracic acid of the boiling springs with soda. They have not as yet completed their arrangements, and have therefore prepared thus far comparatively little for the Eastern market.

Hitherto, we have been supplied with borax from Thibet and Persia, by the way of Calcutta; from Tuscany; and on this continent, from Peru and Ecuador. That from Thibet and Persia is obtained from lakes; that of Tuscany is produced artificially, from boracic acid springs, by reaction between the acid solution and carbonate of soda. South American borax is obtained by the purification of a mineral consisting in large measure of borate of soda and borate of lime. In a short time we shall, no doubt, be chiefly supplied from California.

Mr. Peale communicated a record of a portion of 134 soundings, taken by himself, along the Delaware River, at the Water Gap.

DELAWARE WATER GAP.

Record of the depth of water in the Delaware, as ascertained by 134 soundings, begun at the boat-landing, near the old Saw-mill above the Gap, and continued below the Gap, a distance of about 1¼ miles, on the 4th day of October, 1859; the river being at the average low water mark.

	Feet.	Inches.
Stern of the batteau,	3	4
At intervals, to the Bar,	4	
	4	6
	4	9
	4	6
	4	
	3	9
	3	
	2	9
	3	
	2	9
On the Bar,	2	3
	3	
	6	
	8	6
Middle Channel,	10	
	8	
Opposite small house on the Jersey shore,	9	
	8	9
	10	6
	11	
	12	
Opposite Lover's Leap,	13	
	12	9
	13	
Rebecca's Well,	15	6
	14	
	13	6
Old house on Pennsylvania side,	14	3

	Feet.	Inches.
Prospect Rock,	15	
	16	6
	17	6
	18	
Poplars on Jersey shore,	19	
	21	
	22	9
Above Point of Rocks,	23	
Sandy Bottom,	26	
	28	
Rocky Bottom, which runs from the shore, reducing the depth, as follows,	31	6
	24	
	20	
Thirty or forty feet further east,	27	
Point of Rocks,	25	
	26	
	23	
Sandy Bottom,	20	
Indian Mound, Stony Bottom,	18	
Creek Mouth from Dunfield's Hollow,	22	
	21	
Sandy Bottom,	22	
Slate Factory,	21	9
	19	3
	20	
Pennsylvania Mountain,	21	
	19	6
	18	
	17	6
	16	6
Between Pennsylvania and Jersey Mountains,	15	
	14	6
	13	
Outside, or below Pennsylvania Mountain,	16	
	17	
	18	6
	19	6
Muddy Bottom,	20	
	21	6

	Feet.	Inches.
	23	
	24	
Sandy Bottom,	27	
	33	
	35	
	36	6
Jersey Mountain Rocks dipping at a steep inclination into the River, ...	38	
	31	
	38	6
	33	
	30	
	32	6
Sand and rocks,	31	6
	33	
Outside the Gap, Sandy Bottom, . . .	37	6
	37	
	36	
	35	
	30	

The river decreases regularly in depth to the rapids below the Gap.

Opposite the "Indian Ladder," in a cove near shore, several soundings were made; the greatest depth of water was found to be 45 feet.

Mr. Peale observed that marks of water action were observable on portions of the rock at a considerable elevation above the present bed of the river; but if the theory of erosion, for the formation of the Gap, be accepted, a difficulty is presented by the depth of the water in the Gap, as shown by the soundings in the foregoing record, and the consequent gentle flow of the current; whilst at the distance of one and a quarter miles above and five hundred yards below the Gap the rapids occur, with insufficient water to float the rafts, which, consequently, are obliged to await the spring and fall freshets.

The constant rise of gas, observable from the deepest parts of the water, was also adverted to, as having a possible action in the formation of the Gap.

Remarks on the cause of the gaps and their relation to the general structure were made by Mr. Lesley.

Stated Meeting, December 2, 1864.

Present, twenty-six members.

Judge SHARSWOOD, Vice-President, in the Chair.

Mr. Hilgard, Mr. Harrison, Mr. Joseph Lesley and President Smith, of Girard College, were introduced to the presiding officer, and took their seats as members. Captain Goodman, of the New Hampshire Historical Society, and Mr. L. Thurlow, of Wilkesbarre, were also introduced.

A letter addressed to the President by a claimant for the Magellanic Premium, but without the required sealed packet, accompanying the claim, was read, and on motion, laid on the table. It described an invention for the safety of passengers at sea, and was illustrated by a model.

A letter accepting membership was received from Mr. R. H. Lamborn, dated Altoona, November 17th, 1864.

Donations for the Library were received from the New Hampshire Historical Society; the Franklin Institute; Captain Goodman, and Mr. Lamborn.

The death of the Hon. Roger B. Taney, Chief Justice of the United States, a member of this Society, on the 12th day of October, 1864, aged 87 years, was announced by the Secretary, and on motion, Judge Sharswood was appointed to write an obituary notice of the deceased.

The death of Professor Benjamin Silliman, a member of this Society, at New Haven, November 25th, 1864, aged eighty-four years, was announced by the Secretary, and Professor Pierce appointed to prepare an obituary notice of the deceased.

A photograph and description of the Great Pittsburg Gun, now mounted at Fort Hamilton, was communicated by Mr. Lamborn, with the following letter from Mr. Charles Knap, dated Fort Pitt Foundry, Pittsburg, November 4th, 1864.

The idea of a twenty inch gun was conceived by Major T. J. Rodman, of the Army Ordnance Corps, and the gun in question was designed by him, and made after his method of "Hollow Casting." It required for its manufacture, new furnaces, cranes and lathes, full

descriptions of which were given in the Philadelphia *Press*, of February 12th or 13th, 1864.

The gun was cast on February 11th, 1864, from three large furnaces, containing 80 tons of iron. It was cast hollow, and cooled by means of a stream of cold air forced through the bore from an ordinary fan. Air was preferred to the usual stream of water, on account of the great size of the mass, which increased the danger of creating a dangerous amount of shrinkage. The second twenty inch gun, however, made for the Navy, was cooled by water, without injury.

The cooling occupied two weeks.

The principal weights and dimensions of the gun are as follows, viz.:

Rough weight,	160,000 pounds.
" length,	25 feet, 8 inches.
" maximum diameter,	66 "
" minimum "	48 "
" diameter of bore,	19 "
Finished weight,	116,497 pounds.
" extreme length,	20 feet, 3 inches.
" " " of bore,	210 "
" maximum diameter,	64 "
" minimum "	34 "
" length of elliptical chamber of bore,	15 "

The trunnions were set over the centre of gravity of the gun.

All of the calculations of weights and centre of gravity, made by Major Rodman, and verified here, proved from the results to have been extremely accurate.

The iron used was all made in Blair County, Pennsylvania, and was the best quality of warm blast charcoal pig, remelted once into second fusion pigs, from which, the gun was made.

Specimens from the head gave a density of 7.31 and a tenacity of 36,000 pounds per square inch. A specimen from the breech journal gave a density of 7.3715 and tenacity of 43,746 pounds per square inch. The density is taken with distilled water, and reduced to the common comparative standard of 60° F.

The cost was about $32,000; others could be made much cheaper.

From the commencement of the first preparations to the completion of the recent trial at Fort Hamilton, New York, not a single error or mishap has occurred, to mar the complete success of this last enormous stride in advance of all experience in Artillery.

Letters were received from Professor Zantedeschi, dated Padua, September 11th and November 7th, 1864, a translation of one of which was read, as follows:

I have the honor to forward to your honorable Society, a copy of my letters on the origin of the dew and of the hoarfrost. I here briefly sum up the principal heads of my observations. Can these, my sheets, be published in the Transactions of the Society, my studies may gain such notice, that physicists on the virgin soil of America may repeat my experiments. Remote from the polemics, I confine myself to the fundamental facts of science.

The mode of the manifestation of the dew and the hoarfrost; its sublimation from the soil, from the hour next the setting sun up to the following morning, in the hour next the sunrise, which is the hour of greatest cold, was the subject of my first series of experiments; the circumstances which accompany these phenomena (meteora) were diligently examined in all the calm and serene nights, in which in Italy and in the environs of Paris I made my observations. I find that there is a limit, beyond which dew and hoarfrost is not sensible; and that the limit varies with the variations of the grade of humidity and temperature of the air.

With comparative experiments I have determined whence proceed the aqueous vapor necessary to form dew and hoarfrost. It comes neither wholly from the air by refrigeration, nor wholly from the earth. The greater part rises from the earth, to which is added afterwards, some from the supersaturation of the air; and, it ought not to be forgotten, some from evaporation from the leaves of plants, which is in least quantity. The mean relative humidity of the garden, in which I made my observations, was 55 degrees of the Hygrometer of Saussure. The Hygrometer which received the humidity of the air alone, never rose during the hour of greatest cold to 70°; the Hygrometer which received the moisture from the air and from the earth, went up to 95°; and the Hygrometer which received the moisture from the earth and from the leaves of some small plants, reached the maximum of humidity, 109°. In this way I discovered that the relative humidity of the air was 50°, that of the earth 25°; that of the evaporation of the leaves of plants 5°. These numbers are not absolute. They will vary with the various circumstances of the atmosphere; those of temperature of relative humidity, in nights continually calm and serene; but in all circumstances the abundance of aqueous vapor coming from the earth, was

always greater than that from the supersaturation of the air; and that from the evaporation from plants was always less. The experiment seems entirely new and decisive.

I studied with repeated and laborious experiments to determine the source of the cold necessary for condensing the aqueous vapor forming dew and hoarfrost. By comparative observations I have convinced myself, that the frost of the air precedes that of the moist solids, and that the moist solids do not chill below the temperature of the circumstanding air, taken at the mean height, always in calm and serene nights. It was made apparent by my vertical balance Anemoscope that the nocturnal frost derived itself from the column of cold descending air. I recognized the fact that the surface of the soil, and even of the snow covering it, is always colder than the stratum of air above it; and that with every departure from this stratum the temperature of the air is increased. In all these *facts*, I have done justice to all the physicists who have preceded me, and I register that which is granted to my observations and experiments from my friends.

I have not forgotten to verify the influence exerted by electricity on the deposition of aqueous vapor on solids. I finish these my letters, with two useful applications to Agriculture and to Hygiene, always under guidance of history and experience.

I beg physicists living in the open country in serene and calm nights to repeat all these observations, which complete the theory of the dew and the hoarfrost. May this, my request, obtain favor from your honorable Society, to which, I declare myself with the highest esteem and perfect observance, ZANTEDESCHI.

PADOVA, September 11th, 1864.

An enamelled portrait of a French gentleman, concealed in the bottom of an inkstand or wafer-box, and thrown out by the workmen in digging the foundation for an enlargement of a house, originally built in 1785, at Valley Forge (the headquarters of General Washington, in the winter of 1776), was exhibited to the members by Mr. T. P. James. The relic is, apparently, a work of art of the age of Louis XVI; and much pains has been fruitlessly expended for its identification, both in Europe and in this country.

Mr. Dubois placed before the Society, specimens of Magnesium, lately procured from London for the Cabinet of the Mint, and for experiment.

Magnesium wire is not an entirely new article in this country; but perhaps the ingot is so, and is especially curious. Of all the metals which remain fixed in open air, this is the lightest; the sp. gr. being 1.70, or less than one-twelfth that of platinum, which stands at the other extreme of the scale (and of which a specimen weighing one-third more than the magnesium, is shown for comparison).

This metal is now readily manufactured in England, by a process patented in 1863, and is sold in London at a price equal to $5.25 in gold, per ounce, av'd. Its physical properties are such as to give little promise of utility, except for the purpose of illumination. A wire of this metal, held in an ordinary flame, ignites and burns with a dazzling brilliancy, giving out a white light. On this account it is used in photography, to take pictures at night, or in places where the sun cannot penetrate. The wire appears ductile and pliable, but has really not much tenacity, and snaps off when bent around to the horseshoe shape. It is, in fact, not formed by rolling and drawing, but by the hydrostatic press, from the solid cake; somewhat as lead pipe is made. This specimen has a diameter of one-sixtieth of an inch. One hundred inches of such wire will weigh about fifteen grains, and would cost eighteen cents (gold) in London, at the rate above stated.

The metal being too brittle to be cut with a chisel, this piece of ingot, as will be seen, has been detached by sawing.

Mr. Eckfeldt has made a pretty full examination of its chemical properties, which will here be briefly summed up.

It is slightly soluble in sulphuric acid of commercial strength; the action is violent when the acid is diluted.

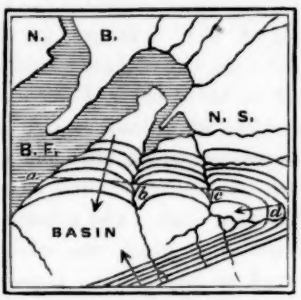
The solution is active and complete in nitric and muriatic acids of ordinary strength.

It is also dissolved by the vegetable acids, such as the acetic and tartaric, but slowly by the oxalic. In a solution of carbonate of soda it dissolves very slowly, but more actively with heat, when it is converted into a carbonate. In caustic potassa there is no action.

It is not affected by water, either at 60° F. or at the boiling-point, except to produce a slight tarnish. The water, however, is decomposed by it. Moist air makes a slight oxidation. These specimens came across the ocean, however, in a paper box, without losing the metallic lustre.

The Librarian communicated an extract from a letter of Mr. W. A. Hendry, of the Crown Land Office, at Halifax, respecting the discovery of a large bed of coal among the lean beds of the Joggins and Albert Mine regions:

"No new discoveries have been made, since you were here, except perhaps at the Spring Hill, which I visited two months ago. You recollect its position on the map. A discovery has been made of a seam of coal, said to be 16 feet thick. I myself measured nearly 14 feet; but 16 and 18 feet has been currently reported as the thickness of the great coal-seam of Spring Hill. The bed, with thin clay partings, gives from 12 to 14 feet of good bituminous coal. I am well acquainted with the gentlemen who are geologists there, Messrs. Mills & Sherer." It is well known that of more than a hundred coal-beds outcropping among these measures on the coast of the Joggins, not one is much more than 4 feet. It is noticeable that this large increase in the size of one of these beds, that at Spring Hill, takes place at the head of a synclinal axis, towards the east, as shown in the diagram.



B. F. Bay of Fundy.
N. B. New Brunswick.
N. S. Nova Scotia.
a. The Joggins Mines.
b. The Victoria Mines.
c. The Macan Mines.
d. The Spring Hill Mine.

The following summary of the rocks passed through in an old salt boring in Clearfield County, Pennsylvania, was communicated by the Librarian, from a letter from Mr. John M. Hale, of Reading. The Librarian remarked, in offering the section, that, it was one of the most useful duties of learned Societies to obtain, and place on record, the too easily lost or destroyed results of the labors of the past.

"Some twenty-five years since, a company bored for Salt Water, at the junction of the Beaver Dam and Eastern branches of the Clearfield Creek, where a natural salt lick existed, and employed Mr. S. G. Wilson to superintend the operations; and to him I am indebted for a copy of his notes, a synopsis of which I thought might be interesting to you, if you have not seen them.

"The first 23 feet was through the clay, where the rock was struck, 7 feet of which was black slate, followed by 6 inches of Bituminous Coal. At a depth of 32 feet, 6 inches, a vein of fire brick rock was struck, which was 13 feet in thickness, and which appeared in the lower part of the vein to be mixed with Iron Ore. The next 5 feet, of black slate mixed in with coal, followed by 1 foot of white flint rock, then 2 feet, 6 inches, of black slate, when a vein of Cannel Coal was struck. This was at a depth of 53 feet. Next, 8 inches of slate, which separated the Cannel Coal from a vein of bituminous coal, 4 feet, 4 inches, in thickness. Then 14 feet of common sandstone, and 2 feet mixed with slate and coal. Then a vein 60 feet in thickness of Porcelain Clay, of a very superior quality, resembling white lead, ground in oil. The next 135 feet was through common sandstone, changing in color from brown to black, and mixed with quartz. Again the auger passed through a vein of 5 feet of Porcelain Clay. The balance was through a vein of hard sandstone, a portion of which was mixed with a yellow metal, which was believed to be copper. Unfortunately, the only specimen saved by Mr. Wilson, was lost. Was it Iron Pyrites?

"At the depth of 548 feet, salt water was reached, but so mixed with a dark fluid that it was believed to be useless. Was this dark fluid Petroleum?

"The veins of coal may be the same as those at Oseola, or the one at Philipsburg passed through at a depth of 199 feet."

Mr. Peale took this occasion to exhibit to the Society some fragments of ancient vessels of pottery of large size, and still conserving the impressions of the osier wickerwork baskets, by which they were ornamented. They were found at ancient salt springs in Gallatin County, Illinois, and are made of clay, in which remain visible fragments of fresh-water shells, mixed in to strengthen the clay.

Large quantities of comminuted shells and broken pottery remain near the springs, with other evidences of ancient salt works, of which there is now no knowledge, either recorded or traditionary.

The style of the ornamentation is entirely distinct from that of the Indian pottery of recent date, and the vessels much larger than any made by that race. The inference drawn from these facts is, that they are the reliquæ of the Mound Builders, a race much more advanced in the arts than those which succeeded them.*

* [These fresh-water shells are brought up in evidence by Mr. Winchell, in his

Mr. Lesley announced the discovery, just made, of a remarkable lignite deposit, close to the ore-banks of the Mont Alto Furnace, in Franklin County, Pennsylvania; but owing to the lateness of the hour, begged leave to postpone the exhibition of the specimens on the table, and the description of the deposit, to the next meeting.

The stated business of the meeting being called for, the Treasurer's report was read, and regularly referred to the Finance Committee.

The report of the Publication Committee was read, and referred to the Finance Committee.

The report of the Board of Officers on the application of "Torricelli" for the Magellanic premium was read, and, on motion of Mr. Fraley, it was resolved, that the subject be ordered for discussion at the next meeting of the Society, and that notice be given to the members on the cards, and an advertisement be made for three days before the meeting, in two daily newspapers.

New nomination No. 529 was read.

And the Society was adjourned.

Stated Meeting, December 16th, 1864.

Present, twenty-one members.

Dr. Wood, President, in the Chair.

A letter declining the appointment to prepare an obituary notice of Prof. Silliman, was received from Prof. Pierce, dated Cambridge, December 18th, 1864.

lately published paper on the structure of the prairies; wherein he argues that the prairie deposit was made in a preglacial lake, overspreading the whole Valley of the Mississippi, as far south as Middle Alabama. *Sill. Jour.*, Nov., 1864. Sec.]

Letters of acknowledgment for publications received were read from the Lombardy Institute; R. Saxon Society; Herr Jochmann; the R. Danish Society; the N. H. S. at Emden; the R. Academy at Amsterdam; Batavian Society at Rotterdam; Sir John Herschel; the Lords of the Admiralty; the Society of Arts, and Society of Antiquaries of London; the Natural History Society of Northumberland; the Smithsonian Institution; and the Chicago Historical Society.

Letters of invoice were received from the Societies at Leipsic, Emden, Upsal, Copenhagen, and the Academy at Amsterdam.

Donations for the Library were received from the Royal Societies and Academies at Upsal, Copenhagen, Leipsic, Emden, Amsterdam, Rotterdam, Milan, London, and Dublin; from the German Geological and French Geographical Societies; from Friedlander & Son of Berlin; and Fr. Miller of Amsterdam, booksellers; from Prof. Steenstrup of Copenhagen; Prof. Zantedeschi of Padua; and Elia Lombardini of Milan; from the London Chemical Society, and Sir John Herschel; from the American Academy at Boston; and Essex Institute at Salem; J. E. Cooley, bookseller; and James T. Hodge, geologist, of New York City; the Academy of Natural Sciences, at Philadelphia; the Franklin Institute, and Mr. M. C. Lea.

The Librarian was authorized to complete the set of Proceedings for Sir John Herschel, at his request.

On motion of the Librarian, after reading a letter from Prof. Daniels of Chicago, the Academy of Science at Chicago was placed on the corresponding list.

The death of one of the oldest members of the Society, Mr. Ross Cuthbert, of Berthier (Lanorais), Lower Canada, was reported by the Secretary, on the authority of a private letter from Prof. Hunt of Montreal, as having taken place in 1861.

The death of another member of the Society, Mr. Henry Rowe Schoolcraft, in Washington, on the 11th inst., aged 72, was announced by the Secretary.

Prof. Cresson was excused from preparing an obituary notice of Mr. Waln.

Mr. T. P. James read a paper on the New Mosses which he had detected within the limits of the United States, east of the Mississippi River, intended for the Transactions. On motion the paper was referred to a Committee consisting of Messrs. Durand, Porter of Lancaster, and Aubrey H. Smith.

Mr. Lesley described a recent discovery of Lignite in iron ore at Pond Bank, ten miles east of Chambersburg, in Franklin County, Pennsylvania, and described the importance of the discovery in a theoretical point of view, its analogy with the Brandon deposit in Vermont, and its influence on the determination of the age of the present surface of the land. Specimens from the deposit were exhibited to the members. Mr. Lesley said:

A few days ago, a remarkable instance of the discovery of a tertiary deposit among the Appalachian mountains, similar to that of the celebrated Brandon lignite deposit, in Vermont, has occurred in Southern Central Pennsylvania. The geological importance of these two cases, so far as I am aware the only two on record, can hardly be overestimated. They open again, in the most embarrassing manner, the discussion of the age of the present Silurian, Devonian, and Carboniferous surface. They suggest an entire revolution in the generally accepted modes of regarding the production of our Appalachian topography. They lend a novel interest to the glacial hypothesis; and they help to settle our views on the difficult subject of the confinement of the New Red within its well-known limits, along the south foot of the South Mountain or Blue Ridge range, which I discussed in a brief manner, at the last meeting of the Society.

The lignite was struck in a shaft, at a depth of 40 feet below the surface. It was between 4 and 5 feet thick; under it a stratum of very solid gray sand,* of equal thickness (5–6 ft.); and then lignite more solid and glossy, for seven feet more, to the bottom,† as far as sunk. I have not been able to visit the place, and give this description as it is reported by the shaft-sinker. Large logs of wood were taken from the deposit, specimens of which, I have the pleasure of

* ("Like disintegrating sandstone.")

† ("With here and there a thin streak or vein of hard gray sand.")

exhibiting to the members present. The rings of growth, the rays, and the bark fibre, are as visible as in a fresh butt. The wood is converted partly into a brilliant cannel coal, and the rest of it into common brown coal. No leaves or fruit have as yet been noticed by the workmen; although such may have been overlooked, from want of knowledge of their importance.

It is possible that a large body of this material may exist just where the shaft happened to be sunk; for the Brandon deposit is a mass about 25 (twenty-five) feet square, descending steeply through a hundred fold larger mass of white clay, to a depth of at least 100 (one hundred) feet. But we cannot call it a large body *comparatively* speaking. It is scarcely larger than the trunk of a single one of the giant trees of California; a mere plug of coal thrust vertically downward into a mass of clay. But Prof. Hitchcock expresses the opinion that the Brandon deposit is not "a vertical plug," but a fragment of a regularly steep-dipping stratum of lignite. He dissents expressly from my own view of the case (published in 1857, after I had visited the locality), when he says: "Mr. Lesley imagines that the Brandon deposit is in a hole, like that in Balamacadam, in Ireland. But if he will visit the former, he will find it no more and perhaps rather less in a hole than the other analogous deposits scattered for two hundred miles along the west base of the Green Mountain range. They generally occur in depressions in the limestone floor, or in sheltered valleys, and this is probably why the drift agency did not sweep them away."*

The venerable and candid geologist whose loss we have been called upon so recently and so heartily to deplore, would have taken, perhaps, more delight in the discovery near Chambersburg, than any other man living; and I regret with a very sad feeling the impossibility of comparing notes with him once more upon this old ground of dispute. For he would probably now be convinced that the different facts involved in this phenomenon must be separated; and that we have to keep our eyes open to several collateral but independent trains of geological accidents. The Lignite and the Iron-ore are neither of the same age, nor, strictly speaking, possessed of any structural attribute common to both. I have, therefore, regarded only the lignite deposit as "in a hole;" not by any means the iron ore. This latter I have long ago described as continuously stratified. When Dr. Hitchcock, therefore, in the above quotation from his report, says, that I will find it no more and perhaps less in a hole than the

* Geology of Vermont, 1861, page 238, lines 4–6.

other analogous deposits, &c.," he cannot mean to affirm anything of the lignite; for there are no other analogous *lignite* deposits known, except only the ore which I bring to the notice of the Society to-night. And I expect to receive the evidence, that it also is truly "in a hole;" that is, it will probably be found to be as curious an exception to all the rest of the phenomena of the whole belt of hematite deposits of the Great Valley, for many hundreds of miles in Pennsylvania and Virginia, as the little plug of lignite at Brandon is an exception to all the other features not only of the great Brandon ore bed, but of all that belt of similar ore beds which ranges for several hundred miles through Vermont, Massachusetts, and New York.

Geologists will appreciate the assertion that it is the extreme rarity of these lignite apparitions in one of the most wonderfully continuous, extensive and valuable ore belts of the world, that gives them all their importance, and produces all our embarrassment. It is therefore of prime importance to make sure of this fact, viz., of the actual rarity of the presence of lignite, or its equivalents, in the ore deposits, and to keep this rarity always in mind, in discussing the age of the ore belt itself; but this Dr. Hitchcock has not done.

On pages 234–236 of the Vermont Report, he says: "Wherever we have found brown hematite and manganese, or beds of ochre, or pipe clay, white, yellow or red, in connection with coarse sand or gravel, all lying beneath the drift, and resting on the rocks beneath, we have regarded the deposit as an equivalent of that at Brandon just described, even though not more than one or two of the substances named be present." The peculiar feature of the Brandon mine is therefore ignored by being confused with others, common to the whole belt.

Dr. Hitchcock gives a list of 26 such deposits along the western side of the Green Mountain range, premising that: "from Stamford through Bennington, as far as Middlebury, it would probably not exceed the truth to represent it as a continuous narrow belt. North of Middlebury the localities are few, perhaps from denudation." Yet along this "probably continuous" belt, he can enumerate, with exception of the Brandon mine, only *one*, that of East Bennington, which exhibits even so much analogy to a lignite deposit as "pipe clay with numerous stems of plants;" and only six others, wherein white clay, ochre, ochres and clay, or lithomarge, suggest to his mind an analogy with the Brandon kaolin.

Now it is quite as safe to call the continuation of the line of the Vermont ore deposits, through Massachusetts, New York, New Jer-

sey, Pennsylvania, Maryland, Virginia, and East Tennessee to Alabama, "a narrow continuous" belt; for, with one exception, hereafter to be described, it is really such. And it would be quite as difficult to point out another deposit strictly "analogous to the Brandon lignite," along all these many hundred miles, excepting the one just discovered in Southern Pennsylvania. There may be others not yet made known. But a great number, literally thousands of shafts, and open quarries, have been made in this ore belt in these different States, during the last hundred years, from some of which hundreds of thousands of tons of stuff have been excavated; and yet even the presence of a fossil leaf, or any other slight trace of tertiary vegetation, is almost or quite unknown. Quantities of dark and even black clay have been obtained; but in all instances, so far as I am aware, the coloring matter has been manganese rather than carbon. The future may reveal much which we do not expect; but enough has been done to prove the rarity of lignite in the ore belt.

We must therefore carefully separate these sporadic occurrences of lignite from the general occurrence of iron ore, in our discussion.

I think it can be shown, also, that we must keep quite as separate the lignite and the clays. And I think it can also be shown that the clays are to be connected closely with the ores, instead of with the lignite, if we are to reach clear views of the whole phenomenon.

These are the principal features of the great ore belt of the Atlantic States:

1. It occupies a narrow strip of surface, along the Great (Lower Silurian) Valley, which begins in Canada, and ends in Alabama.

2. It hugs the southeastern margin of the Great Valley, and lies at and against the foot of the Mountain Barrier, which, as is well known, shuts the Great Valley in from the Atlantic seaboard; a barrier, known by various names, such as the Green Mountains, the Highlands, the South Mountains, the Blue Ridge, and the Smoky Mountains; but which is in reality and geologically considered, one continuous range or ridge of rock.

3. It lies, therefore, over the lower contact of the Lower Silurian limestones with and upon the rocks of the Great Barrier range; and is, therefore, *in some way or other*, genetically involved in that contact. It therefore belongs geologically to the Lower Silurian limestone formation, and especially to the lowest member of that formation; and cannot in any sense, *as an ore belt*, be of tertiary age, without a plain violation of the canons of structural geology.

4. It consists everywhere of two parts, more or less easily dis-

tinguished; the one stratified in the same sense as the Silurian limestones themselves; the other a surface-wash over the basset edges of the first. The date of the formation of this local surface-wash may be tertiary, and perhaps post-tertiary. The stratified portions must be, as to their stratification, of Lower Silurian age; while the metamorphism which they have undergone, *in situ*, productive of stratified clays and ores, *may date from any time subsequent to the formation of a surface topography approximately identical with that which now exists.* The actual change of the original Lower Silurian calcoferriferous sandstones and slates, *in situ*, at their outcrops, into limonite clay beds, *in ipso situ*, stratified as before, but charged with an additional percentage of the oxides from a former higher surface now eroded, and with this extra charge of iron and manganese carried by percolation down to and crystallized against their foot rock,—this change may have required an immense time to perfect, and no doubt was going on, *pari passu* with the degradation of the surface by slow erosion, from higher to lower levels, until it stands at the level of the present day.

This long era of *iron ore concentration*, in the Lower Silurian slates, could not have commenced until after the close of the coal era; and I will be able to show, I think, not until after the close of the New Red or Middle Secondary age. It may have been commensurate with the Cretaceous, Tertiary and Recent periods together; or with the Tertiary or the latest Tertiary and Recent alone. But it seems more likely, in view of the geographical relationships of the New Red to the Silurian on one side of it, and to the Cretaceous on the other side of it, that the erosion of the surface commenced at the close of the New Red era, and continued without intermission down to the present day. There is no sufficient evidence of the submergence of the Atlantic side of the Continent, since its emergence after the coal. There is not a trace of New Red, Cretaceous, or Tertiary deposit recorded by any geologist, so far as I am aware, over all the country back of the Great Barrier range, from west of the Hudson, until we reach the prairie lands of the Mississippi Valley. There were, of course, New Red rivers, Cretaceous brooks, Tertiary freshets, Glacial ice; but these carved out the present surface-topography of the Appalachians, without leaving a plant, an animal, or even a pebble which can be recognized as belonging to any special age. In fact, the New Red surface must have been largely remodelled, lowered, and denuded of New Red relics, by the Cretaceous agents; and the same liberties were no doubt taken with the

surface of the Cretaceous age, by the sweeping and garnishing artists of Tertiary times. Little by little the whole sloping mean horizon of water-level, from the Alleghany Mountain to the South Mountain, was lowered to its present line. The gaps were gradually deepened, widened, and rounded off to correspond with the slow deepening of the limestone and slate valleys behind them; and the long strait narrow sandstone crests of the mountains of IV and X and XII (Middle Silurian, Upper Devonian, and Carboniferous), were gnawed away evenly at a slower but not less steady rate.

It was Professor Rogers's opinion that all this was, so to speak, the work of a moment; the consequence of the rush of a large body of water over the face of the Continent, at the time when the coal era was abruptly brought to a termination by the upheaval into the air of the whole Appalachian belt of earth-crust, when it was thrown into waves or folds; after which the once horizontal strata remained partly or entirely upright.

With this cataclysmic hypothesis I cordially sympathized for some years; and some of the geologists of the Pennsylvania survey, I believe, still do so. Nor am I yet entirely convinced,—it may be from the force of a strong and early prejudice,—that such a cataclysm is not indispensable to explain the earlier and perhaps the larger part of the whole phenomenon. Not that I ever accepted that part of Mr. Rogers's statement of it which gave an account of the *modus operandi* of the anticlinals, viz.: by a pulsating planetary lava-nucleus. But the study of the surface itself, covered with mountains and valleys, arranged in a beautifully symmetrical manner, by whatever energy you please,—and I have always thought the lateral thrust of a cooling and shrinking crust one sufficiently plain and precisely explanatory of the details,—in fact, the study of these details, some of which offer the most inviting problems of erosion to the structural geologist, has impressed upon my mind the conviction that aërial and fluvial agents are not the *kind* which could have *begun* the great work of Appalachian erosion. Give them time and they are omnipotent, I grant, *but only in their own sphere.*

It would lead too far to argue this part of the subject here. I only wish, when I describe the whole water-shed horizon of the Appalachians as being step by step lowered during later Secondary, Tertiary, and Quaternary times, to guard against that total rejection of cataclysmic agency which has come to characterize the geological speculation of the present day upon great structural questions. This fact, evidently true in itself, is also necessary to the argument respecting

the Tertiary age of the iron ore beds containing lignite. In fine, it is the main fact of the discussion.

The gradual lowering of the main surface-plane involved, 1st, the obliteration of all grand original inequalities which would have been produced by a grand original cataclysm, if a cataclysm be allowed; and, 2d, the production of a new set of inequalities, due partly to structural relations of movement, such as folds and faults, but chiefly to the different *homogeneousness*, the different *compactness*, and the different *insolubility* of the formations. These three chemical and lithological differences, of course, produced our present mountain, hill, and valley surface. It is evident, then, that the reason why the southeast side of the Great Valley is everywhere lower than the northwest side, is because it represents the more soluble and less compact outcrop edges of the Lower Silurian limestones No. II, while the other, or northwest side of the Great Valley, consists of Lower Silurian slates No. III. In fact, the Great Valley may be said to be as to the northwest half of it paved with low hills. These are the slate hills of that half of the valley which lies up against the North (Kittatinny, Blue or Brush) Mountain. The southeast half is a nearly perfect plain, cultivated like a garden, and exhibiting in the fields numberless low ledges of limestone rock, beside many of which stand limekilns.

There are certainly evidences of some obscure nonconformability between the limestones of II and the slates of III above them; for, while the strike of the slates is always straight up and down the Valley, that of many groups of these limestone-outcrops is perversely out of line, often crossing the valley at various and sometimes at right angles. But much of this apparent nonconformability is no doubt due to crimpling, although the whole formation is much more nearly horizontal than it has had credit given to it for being; and much of it is a deception, produced by an extraordinarily well-developed system of cleavage-planes. On the whole, the regularity of the bounding mountains, and the symmetry of the Valley itself, are good guarantees against any serious nonconformability.

Before the beginning, and again, after the close of the *limestone* Lower Silurian age, there were depositions of ferruginous mud, causing two slate formations, a lower, No. I, and an upper, No. III. The contact of the limestone and the upper slate, along the central line of the Valley, is marked by a range of iron ore. In a few instances it is abundant and largely excavated for the furnaces of Pennsylvania.

The contact-line of slates just under the limestone No. II, with

the lowest sandy layers of the limestone, gives us likewise a second great belt of iron ore deposits, lying along the foot and part way up the side of the South Mountain. These are the deposits of which Professor Hitchcock speaks in Vermont; and in one of these in Pennsylvania, viz., in the Pond-bank of Mont Alto Furnace, the lignite has been found.

Along the foot of the South Mountain, the feebler brooks, descending from the ravines, sink immediately beneath the surface into a system of underground caverns, which may, without much exaggeration, be called a single cave, extending for a thousand miles, and including in its course chambers, some of which, like Weir's Cave, in Virginia, have become celebrated among the wonders of the world. The stronger brooks unite, and form large streams, or even rivers, which,—like the Lehigh below Allentown, the Yellow Breeches west of the Susquehanna, the Shenandoah south of the Potomac,—flow close over the southern or lower edge of the limestone formation, and therefore close up to the foot of the mountain.

Both this situation of the river drainage on the surface, and this cavern system underneath, tell one story, which cannot be misinterpreted,—the *extra dissolubility of this particular horizon of Lower Silurian rocks.* And that, which we now see going on before our eyes, has, of course, been going on for ages. The fissures which are now being enlarged into caves, and the caves which are fast growing into catacombs, and ramifying into labyrinths of underground darkness, their roofs every now and then falling, so as to produce funnel-shaped sinkholes in the fields and sometimes in the roads, and their floors receiving, through the sinkholes, lots of leaves and fruit, land shells, and perhaps occasionally bones of smaller animals, with every great spring freshet,—all these once had their analogues in time past (vanished now into thin air) beneath some old surface, situated many feet or yards, in fact many fathoms, above the one on which men live to-day.

By this ideal reconstruction of surfaces older and above the present one, we settle most of the difficulties which encounter us in studying the ores of the Great Valley. And I submit, that we obtain, also, a reasonable explanation of the sporadic masses of lignite, two of which are now known to exist in or rather near the iron ore; for it must not be forgotten that the lignite and ore are not in contact at either place. It is only necessary to suppose a sink hole so formed, and so stopped up below, as first to receive and then to retain an accumulation of forest trash, and we have the thing ready

made to our hand. The fact, that it occurred just under, in, or near a great ore deposit, must be regarded as an accident, until we have found enough more lignite deposits connected with ore beds to make some organic or original connection between them supposable. And even then, it must be remembered, that the search is wholly confined to the ore-deposit localities, which of itself would throw doubt upon their connection, even if we had a sufficient number of instances.

I will now give as clear a description as I can of the ore banks of Mont Alto, so as to show, if possible, the actual relationship of the lignite to the ore; granting, in advance, that the description will leave much to be desired.

The brown-hematite ore-deposits of Mont Alto follow the outcrop edges of the slates and sandy limestones which form the southeastern edge of the Valley, as shown in section, Fig. 1, Plate VIII. The ore is in fact nothing but the residue of these beds after decomposition and dissolution, the honeycombed and altered edges of the Silurian slates and sand-limes themselves, after their lime has been washed out of them, and their carbonated and sulphuretted iron has been hydrated and peroxidized. The muddy slates formed the present deposits of small ore with white and red clay. The sandy limestones formed the present harder, silicious, rock-ore belts. The geologist can procure, in the banks, specimens of every stage of this interesting process, from the perfect limestones which refused to disintegrate, and the iron-lime-sandstone with the disintegration and recrystallization begun, to the perfect ball and pot ore of radiated, acicular, crystallized brown-hematite. The great variety in the composition of the original rocks has been the cause of a great diversity in the ores taken from the different openings. But two principal distinctions may be particularly noticed; viz., that the ores which have resulted from the decomposition of the slates are more disposed to the *redshort* side, whereas the ores which have resulted from the decomposition of the limestones are more or less *coldshort;* probably because of the sand in the limestone; it is, in fact, called by the New York geologists the Calciferous Sandrock. The slates, on the contrary, are apt to hold a small percentage of sulphur; or perhaps we should say, are less likely to permit the abundant drainage needful for carrying off the sulphur in the form of a salt. Sometimes in the same deposit there is a mixture of the two varieties, producing a neutral ore. But it is not often that such large exposures of both varieties occur in the same neighborhood, as is the case here.

Taking into view all that we know of these deposits along the

southeast side of the Great Valley, from the Hudson river to Tennessee and Alabama, and adding what we know of similar deposits, produced in a similar way, out of the exposed outcrop edges of the same rocks in the limestone valleys further back towards the Allegheny Mountains (such as Kishicoquillis, Nittany, &c.), and deposits, in the same geological positions in Lancaster and Chester counties, we can divide them with great certainty, as stated above, into two classes, the *slate-crop banks*, and the *sand-lime-crop banks*, the former being always geologically underneath the latter, as represented in Fig. 1.

The cavernous condition of the formation which crosses the Antietam creek at Mont Alto is evinced by the numerous sink-holes and ponds lined with clay, and by the absence of small streams, and by the curious topography of the whole slope of the South Mountain, the want of any definite run to the vales, the bowl-shaped aspect of every part of the surface, and the disappearance of the mountain brooks on their way towards the centre of the valley. In other valleys (as e. x. in Sinking Creek Valley, near Altoona) the number and the extent of the caverns astonish and delight the beholder. Where the dip of the rocks is steep there is not the same chance for the formation of caverns; and the depth to which the disintegration of bed, in other words, the formation of ore, can go, is necessarily limited. On the contrary, where the dip is gentle the dissolution is extensive, and the ore abundant.

Within the first half mile there have been excavated several large pits. The bank at present wrought is 2200 feet from the furnace. It is called the Home-bank, and furnishes the principal data for estimating the quantities of ore in the whole belt, Fig. 2.

The excavation is between one and two hundred feet long, and of the shape shown in the figure. Its mouth is a cartway between walls of surface clay or common stripping. Its head is a steep slope of clay, covering ore, from 40 to 50 feet high, behind the top of which rises the mountain side 50 feet higher, to a gently sloping terrace, as shown section, Fig. 3.

As there are but from 5 to 10 feet of stripping, and the ore in fact sometimes comes within that distance of the surface, the plan shows at a glance the immense extent of the ore ground. The new workings are ordinary gangways, timbered and lagged where needful, with cross galleries driven to the right and left, in an irregular manner, but so as to leave 50 foot pillars of ore between them, and not kept carefully upon a level. In fact, one of the gangways to the

right rises so fast as to overrun the timbers of the old tunnel (See Fig. 2) which is driven into the face of the quarry at a level 20 or 30 feet higher than c. Another gallery has a shaft 30 feet deep at its end. The whole mine is in fact nothing but an extensive shaft exploration, leaving the mass of the ore untouched. We have, therefore, data in sight for the following calculation:

Quantity of Ore in the Mine, in Sight.

Galleries one way, 200 + feet = 70 yards,	
Galleries the other way, 150 feet = 50 yards,	say 60,000 cubic yards.
Average height above tunnel, 50 + feet = 17 yards,	
Add length of quarry, 150 + 150 feet = 100 yards,	
Take same breadth as above (200) = 70 yards,	say 175,000 cubic yards.
Depth of shaft in quarry, (70 +) = 25 yards,	
To which add for quarry slopes, &c.,	say 15,000 cubic yards.
Total in sight of the Home-bank,	say 250,000 cubic yards.

This does not take into account the existence of ore to a greater depth than the bottom of the shaft, 70 feet, where, as the miners assert, they stopped in solid ore; and there is no reason to doubt the fact, seeing 1, that the 30-foot shaft, at the inner end of the side gallery, left off in ore, and the dip would carry it far below the bottom of the 70-foot shaft; and, 2, the bottom of the 70-foot shaft is still 70 feet above the creek at the furnace, and therefore within the limits of underground drainage and decomposition. It is also left out of sight, in the above calculation, that the ore passes outward and downward from the quarry in the direction of x, (Fig. 3), all of which must be added to the sum total above.

Thus, a surface section of the ore belt 50 yards long represents ore beneath it to the extent of, say 250,000 cubic yards.

The mining done in past years from this bank half way to the furnace, and the exhibitions of ore at the surface at the furnace, warrant us in using the above calculation for that distance, viz., 2200 feet, or say 700 yards, = 3,500,000 cubic yards of ore in the ground.

Openings made, also, at intervals, beyond the Home-bank, to a distance of a mile and a quarter from the furnace, will, on the above calculation, increase this quantity to 11,000,000 cubic yards of ore in the ground. There is no reason for doubting that the ore belt continues equally rich to a greater distance northward, along the face of the mountain, past the White Rock Gap, and towards the Conecocheague, at Caledonia Iron Works. But as the surface exposures can never be implicitly relied on, and as the quantity of ore depends more upon the local depth of drainage and decomposition than upon any

other consideration, it is hazardous to extend the calculation further. Towards Quincy and Waynesborough, no good openings have been made in that part of the belt, although the surface is covered with blocks of ore, and the wash ore is seen in the roads. It is probable that as large an amount can be obtained south of Mont Alto Furnace as north of it.

The ore in the ground consists of ball ore and wash ore, with lumps, plates, and streaks of clay. The clay is thrown out where it is in sufficiently large lumps, and the rest of it is washed off. There remains a good deal of clay in the balls, which are irregular globes of hematite, oftentimes hollow, and lined with beautiful acicular crystals, standing apart like the bristles of a brush, but set at an angle with the inside face of the shell.

The ore when washed is about a 50 per cent. ore, the books showing that 4600 pounds of washed ore made a (long) ton of iron.

Professor Booth's analysis gave:

Sesquioxide of iron, ...	75.00
Alumina, ...	1.00
Silica, ...	16.00
Water, ...	8.00

(omitting decimals) with a trace of lime remaining. The iron has always been inclined to coldshort, on account of the silica, and has usually been mixed with ore from the Pond-banks (to be described below), when it makes a very tough iron. Tested in Washington, with three other varieties of iron, it stood as follows:

Tredegar iron sustained	32,000	pounds.
Ulster " "	32,000	"
Glendon " "	34,000	"
Mt. Alto " "	34,000	"

(decimals omitted), the test bar being round, and its section equal to a square of .75 inch.

To get the percentage of lump clay, I calculated the contents of the tip-heap in front of the old tunnel, b, out of which it was taken, and from which were also taken the proceeds of two years' mining for the furnace, say 4000 tons of ore. The tip-heap contained about 100 cubic yards of clay refuse.

I also saw washed 13 barrows of "wash ore," containing no lump clay, and saw that they yielded 11¼ barrows of washed ore ready for the roasting pile; = 90 per cent.

The proportion of *lump clay* in this tunnel to *unwashed ore* must have been, say from 5 to 10 per cent, by weight.

The proportion of clay to ore near the surface is greater than it is further down, probably because the drainage from the surface into the already made ore has charged all its vacancies. But whatever be the explanation, the ore-mass becomes denser and richer continually as one descends in the quarry, and the deepest shafts sunk have left off in very hard, pure ore. In the limestone deposits of pipe ore, the lower limit or extreme bottom plane of dissolution is characterized by an accumulation of very pure and beautifully crystallized hydrated peroxide of iron; and all these deposits are, therefore, richest at the bottom. A mass of rock ore lies thus behind the present works, and below them; or, in other words, forming the "foot-wall" or "underlay" to the deposit. This rock or hard ore is struck in the galleries, and is not worked, because it requires blasting; whereas, all the rest of the mass can be picked and shovelled. In the future open quarries, this mass of ore will form the richest part of the work. It is merely a more compact form of brown hematite, perhaps a little more silicious than the rest. The terrace above the works shows much surface ore, and on this terrace come up the slates which hold the Pond-bank ore, hereafter to be described.

Again, outside, or above, or to the west of, the Home-bank belt (B, of Fig. 2), there is a third belt (C), the outcrop of which is shown by a sharp small ridge in a field, covered with blocks of hard ore from one to two feet in diameter. The whole surface of this sloping field, from the little ridge downwards, for a hundred yards, is strewed with this ore, many tons of which have been collected and smelted in the furnace. It is probably in connection with this ore belt that we find an outcrop of almost unchanged blue carbonate of iron and lime, several feet thick, mottled with groups of crystals of white calc spar, and evidently, in parts, changing into honeycomb brown-hematite ore. It lies with a dip of 20° towards the west.

There are evidences of other belts further west still; and a limestone quarry, used for fluxing the furnace, shows a 45° reverse dip (towards the east), by which we know that there is a basin, running along the bottom of the slope of the mountain, and an anticlinal axis west of it, bringing up the ore-bearing formations towards, and perhaps to, the surface; which is sufficient to account for the ore belts just mentioned.

This synclinal axis is the same which runs in between the Little

Mountain and the Main Mountain at the Pond-banks (or rather at the English openings; see the map, Plate IX). The anticlinal axis is no doubt that of the Little Mountain itself, which brings up the slates on the back of the Potsdam sandstone, and thus produces the grand exhibitions of ore all around it, as shown in Fig. 4.

The Pond-banks and Caledonia-bank, and the English diggings, are several openings of greater or less size in the upturned belt of slates surrounding the Little Mountain, which rises as an isolated ridge, one or two miles long, from the floor of the valley. The English diggings are behind it, the Caledonia-bank before it, and the Pond-banks at its south end, in the plain. The ore mass in the Caledonia-bank dips 5° towards the mountain, but must certainly rise again upon its flank. The English ore evidently dips 10°—15° away from the mountain. The difficulty of estimating the quantity of ore on this ground is very great, on account of the enormous covering of red earth upon it in places. The shape of this deep excavation is that of a crescent, with nearly vertical sides, and an irregular bottom.* Its whole length is about three hundred yards, and its depth to the general floor is from 60 to 80 feet. The ore appears within 10 to 20 feet of the surface, at some points, and at others not for 30 or 40 feet down. Mountains of stripping stand beside it to the west, above where the body of the ore turns over a small anticlinal, and buries itself westward beneath undecomposed limestone. The depth of the ore is still unknown. Shafts from 60 to 110 feet have been sunk in it at the sides and in the bottom of the present excavation. The top of the ore stratum at the extreme north end of the quarry is exactly on a level with the edge of the upper Pond-bank, which is only 5 or 10 feet above the top of its own ore, into which the mining has descended 30 to 40 feet. The lower Pond-bank is on a slightly higher level.

The fact is, therefore, that all these three excavations, separated by only one or two hundred yards of interval from each other, and extending in a line about one thousand yards, are sunk in one deposit of ore; or, to speak more correctly, in the broad overlapping margin of the ore-bearing slate deposit, which sweeps round the south end of the Little Mountain in a nearly horizontal and partly basin-shaped posture.

In the bottom of these excavations the ore is reported as uniformly well compacted. In the upper end (north end) of the Caledonia-

* The sketch Fig. 8, Plate X, was made from the head of the road.

bank at a depth of say 60 feet from the surface, I saw the top of a body of ore which was as solid as a mass of cellular brown-hematite ore could be. In other parts the ore is distributed through clay. The whole is worked with pick and shovel. The large tip-heaps at Caledonia-bank show the quantity of stripping done, rather than the amount of clay mixed with the ore, and the small size of the tip-heaps about the two Pond-banks speak well for a large percentage of ore in proportion to clay.

Taking, then, the length and the width of the three banks for a basis of calculation, and giving only 50 feet as the average depth of the ore, and deducting 50 per cent. for clay (which is very large), we see: 1000 yds. $\times$100 yds. $\times$17 yds. $\div$2=850,000 cubic yards of ore in the ground, from which the extracted ore has been deducted. Starting with this amount of ore "in sight," and applying the calculation to the ore descending on the west, ascending again on the east, outspreading to the south, and filling the little valley behind the Little Mountain, past the English diggings, we get many millions of tons in addition, and under precisely the same conditions, viz. with a variable covering of soil, clay, and loam, say from six to twenty feet thick; nearly horizontal; compact towards the bottom and loaded with clay in places; the ore all in small pots, and shards, and gravel-like pieces; yielding about fifty per cent. of metal, and showing a neutral character, making excellent iron. The amount of clay in these banks is highly in excess of the amount at the Home-banks. On the other hand the amount of silica is less.

The Lower Pond-bank is said to have mined from five to ten thousand tons of ore, beginning within ten feet below the surface, and descending at least thirty feet, without bottom.

The Upper Pond-bank is said to have a depth of forty-three feet in ore, the ore coming to within ten feet of the surface. From the bottom of the original central shaft they drove a tunnel out to daylight, and used it afterwards for hauling out the ore.

The English diggings, on the back of the Little Mountain, are only a trench, fifty feet wide by one hundred and fifty long, and from five to twenty-five feet deep, cut slanting up the side of the mountain (or hill, as it really is not 200 feet high), and showing a white clay covering, massive, eight feet thick, dipping 20° to the eastward. The ore, which is under it, cannot now be seen, because of the condition of the pit; but a set of fresh trial pits, outside of the main pit, show the ore in good condition within five feet of the soil.

A branch railroad from Scotland Station, up the valley of the

Conecocheague, *seven miles*, to the Caledonia and Pond-banks, and thence forward along the ore belt, *two miles*, to the Home-bank, and *one mile* further to Mont Alto Furnace, making ten miles in all, is about to be constructed. The route follows a wide and shallow meadow valley, with a rise (by barometer) of 20 feet in the first four miles; 90 feet in the next three miles, to the first ore beds; and 230 feet for the next two miles, to the Home-bank opening.

The water of the creek at the furnace is 140 feet below the Home-bank, and 200 feet above railroad grade at Scotland Station (measured by one of Becker & Sons' Aneroid Barometers).

It is within a few hundred feet of one of the Pond-banks that the shaft has been sunk, which penetrated the lignite layers; and it will be noticed, that their horizontality is in agreement, 1st, with the horizontality of all the Silurian measures which sweep round the flat south end of the Little Mountain anticlinal; 2dly, with the horizontality of the ore deposits; and, 3dly, with the general plane surface of the locality. There is no good objection to considering the lignite beds a local deposit of late date, made in a shallow pond, produced either by erosion, or by settling, caused by cavern-solution close underneath, and puddled with the ore-clay so as to hold water and maintain a fresh-water vegetation, with which the forest leaves and trees, incessantly discharged by freshets, would be intermingled. This may have happened at any age after the uplift of the palæozoic system and the subsequent production of the present surface, except so much time as may be represented by the forty feet of sand, &c. lying upon the lignite. There is, therefore, to choose from, the whole interval embraced by the Permian, Jurassic, Cretaceous, and Tertiary areas.

To determine this more nearly, there must first be a determination of the relation existing between the surface of the Palæozoic region and the surface of the Permiano-Jurassic region, commonly separated from each other by the mountain barrier of the Highland-South-Mountain-Blue-Ridge range, but touching each other along the remarkable gap in that range, between the Schuylkill and Susquehanna rivers, and represented on the colored map, plate XI. The present relation of the two surfaces to each other, is shown in Fig. 10, plate X, and a selection from some of their supposed relationships in past times is made in Fig. 11. The so-called New Red Estuary rocks are seen in these sections dipping uniformly northwestward, at angles from 20° to 30°. Their highest stratum, the breccia called Potomac Marble, is sometimes a conglomerate of well-rolled pebbles, in which I have often recognized, not only fragments of the Lower

Silurian limestones and slates of II and III; but quartz pebbles from the Middle Silurian (Llandovery) sandstone of IV, or the not much more distant outcrops of the Upper Devonian and Carboniferous conglomerates of X and XII.

The New Red is seen dipping northward against a country which is lower than its own. The question is not one of a fault to produce this dip: 1. Because a fault which should throw the New Red *down*, must necessarily leave the Silurian dominating it from an elevation; 2. Because the dip exists everywhere, along the estuary for 500 miles, where its northern coast is a mountain anticlinal of Azoic, without trace of fault; 3. Because the north edge of the New Red, at the place of section, is scalloped in such a form as no fault of any magnitude could produce; 4. Because the exposures are good and numerous, and yet there is nothing to show the existence of a fault, upon the ground.

The New Red is seen in the section dipping northward against or toward a country, the surface of which is three hundred feet lower than its own. There is no evidence of a wide extension of New Red over that lower surface in the New Red age. On the contrary, not a hillock or gravel patch of New Red is to be found throughout the whole Palæozoic country to the north or west of this, its present absurdly constructed overhanging and outdipping margin. How is this to be accounted for?

There must have been some barrier to the New Red waters between the Schuylkill and the Susquehanna, to correspond with the barrier which we see everywhere else between the Hudson and the James. Otherwise the New Red waters would have overflowed, by *at least* three hundred feet, the Silurian Valley in its rear, and penetrated to valleys still further back by means of the principal gaps in the Kittatinny Mountains through which the Schuylkill, the Swatara, and the Susquehanna rivers flow. What was this barrier ?

I think none can be suggested but one composed of the *originally much more elevated surface of the Silurian Valley itself.* Carry up the whole mean level of the Palæozoic area—the valley beds up to the present height of the mountains, and the mountain crests to a proportionately greater altitude, the gaps to correspond with both, and the anticlinal and synclinal structure to determine the face of the surface at any given stage of the process,—and we have the required barrier to the estuary of the New Red; the explanation of its top Conglomerate; a good reason why there are no New Red traces

back of the South Mountains; and a closer date for the Lignite of Mont Alto.

In Fig. 11, plate X, where such a reconstruction of an ancient surface of the Great Valley is attempted, there is noticeable, 1. How vast an amount of Palæozoic rock-substance has been swept away; and, yet, that amount represents only the waste of the four lower Palæozoic formations; superposed upon these at a still older date, eight others, including the Coal Measures, must have formed their surfaces; supposing no cataclysm. 2. How fine a chance was given for collecting towards the present surface the ferruginous elements of the slowly decomposing and cavernous-becoming limestone layers; and 3. How the erosion must have acted, for some reason or other, more upon the Palæozoic surface outside, than upon the Palæozoic surface inside the limits of the New Red; the reason probably being, simply, this: that the latter was under the New Red waters, and was being covered up, while the other was being eroded; but the erosion had not yet brought the valley surface down to the New Red water-level, when the uplift of the New Red took place. After which, the two erosions went on with different velocities proportional to the different solubilities, &c., of the Silurian limestone, and of the New Red sandstone, formations.

As for the lignite, therefore, it must have been subsequent to the erosion of the New Red, that is, certainly not older than the Cretaceous lignites of the United States; and when we consider the immense lapse of time needful for carrying the Silurian Valley surface from a level with the tops of the New Red Hills, down to a level with their feet, we may well believe that the precise condition of the ore deposits as we see it, while it commenced before New Red times, was not perfected until the latest tertiary age, and, therefore, this last must be the age of the lignite—apart from all consideration of fossils.

[Captain Geo. B. Wiestling, Superintendent at Mont Alto, writes under date of Jan. 20, 1865, as follows:

"Our pit No. 1, primitive iron ore (Pond-bank), lies at the southwest foot of the 'Little Mountain,' close by the township road leading from Greenwood, on the Baltimore turnpike, to Altodale, near our works. About seven hundred (700) feet south of this pit, we have another larger pit, No. 2. These are about three-fourths of a mile west of a spur (Mont Alto) of the South Mountain. The neighborhood is dotted with a number of ponds, from which it derives its name, 'Pond-bank.' In order to drain the water from and

beneath both these pits, we located and sank a shaft between them and nearer the larger pit. Although our judgment would have dictated a locality a little more eastward, to have struck the bed of ore, yet we selected this as more favorable ground for sinking.

"At a depth of five feet from the surface, we came upon the beautiful white clay which lies immediately upon the ore, and is more or less mixed with it.

"At ten feet from the surface we penetrated through the white clay and met a clear, sharp, light colored sand, which continued for about five feet.

"Then we found yellow clay mixed with sand, and spotted with red clay (pigment). This varied but little until we attained a depth of forty (40) feet from the surface, where, at a distinct, decided line, almost horizontal, dipping, if at all, a little south, we encountered a close-grained, tough, black clay, with small particles, as large as a grain of wheat up to a grain of oats, resembling small pieces of charcoal, intermingled with it. This proved only one foot thick; and then, at a depth of forty-one (41) feet from the surface, we came upon the *lignite*.

"After penetrating this four (4) feet, a layer, one foot thick, of a tough, gray, sandy substance, intervened; after which we met a lower stratum of the lignite, apparently growing more solid as we descended.

"Through this we continued to sink, for eighteen feet further, where about one foot of sand covered a beautiful variegated clay, pearl and white body, with crimson and purple streaks through it. At two feet deeper, the southwest corner of the shaft showed pure red, and the northeast corner pure white clay.

"Thus far, then, we had sunk sixty-seven (67) feet from the surface, and had developed two strata of lignite, respectively four (4) feet and eighteen (18) feet thick.

"This depth (67 feet) was more than necessary for our purposes in sinking the shaft, and we commenced a drift or adit, three feet above the bottom of the shaft, in the lignite, in the direction of the layer, pit No. 2 (south). This drift we have driven, to this date, forty-eight (48) feet in the lignite; but yesterday the ground showed evidences of a change to light-colored clay. We have concluded to return to the shaft, and from its bottom sink a smaller pit still deeper, for purposes of observation; a small contribution to science The results I will advise you of as we progress, with pleasure.

"The lignite, when excavated, was solid, rang and glistened like anthracite. Exposure to the air disintegrated it to a certain extent, and impaired its lustre. It burns freely, with a bright flame and intense heat, and proves excellent for generating steam. It cokes beautifully.

"When drying pieces of it (for experiment) on the stove, a considerable quantity of oil fried out, and the empyreumatic odor was very decided. This circumstance, in connection with the fact of a heavy, greasy coating on our springs and streams (heretofore credited to the iron ore), causes considerable speculation as to the existence of petroleum at no great depth.

"In the field lying between the 'Little Mountain' and South Mountain, east of the English-bank, we have sunk a number of test pits. In all but one, we have found ore near the surface. In this exception, located about two hundred feet east of the English-bank, at a depth of fifteen (15) feet, we encountered a black clay, similar to that which immediately overlaid the lignite at the Pond-bank.

"A number of circumstances combined to prevent our sinking the pit any deeper at the time, though we intend developing what lies beneath, in the early spring."]

Mr. Foulke inquired whether or not any of the members present had collected such evidence in relation to deposits of iron, as would throw new light on the origin of such beds.

Mr. Foulke referred to the discovery of the part which infusoria had taken in the formation of silicious rocks, and remarked upon the contributions of the United States Coast Survey; and said, that the fact of assimilation of iron by minute marine animals, might suggest an analogy with Ehrenberg's microscopic results in the origin of beds of iron.

Mr. Lesley remarked upon the appearance of encrinites in strata of carbonate of iron, as interesting exemplifications of the metamorphosis of encrinitic limestone deposits to iron ore beds among the coal measures.

Mr. Foulke recurred to the distinction between the example of carbonate of iron and that which he had presented, viz.: the formation of ore-beds in a manner analogous with those of Ehrenberg's silicious rocks.

Mr. Osborne, present by invitation, exhibited a port-folio of lithographic plates, and explained his process of copying by Photo-lithography. Mr. Osborne said:

This method of combining photography with lithography is not new; it is a tried and tested process, which for upwards of five years, has been actively employed by the government of the British Colony Victoria, for the production of maps. The invention dates from the 19th of August, 1859, and the first official map was produced by it on the 3d of September following; since which time several thousand different original maps have been photo-lithographed by its means, and sold to the public. The saving, both in time and money, which its introduction has effected, is very great; and the government of the colony has erected, according to my suggestion and plan, a substantial office consisting of several rooms, exclusively for the prosecution of this method of reproduction. In 1861, the Victorian Parliament acknowledged my services, and the estimation in which they held the process, by voting me unanimously the sum of £1000.

The general history of photo-lithography, and the details of the various processes which have been put forward from time to time, is a subject too extended for me to discuss on the present occasion; I shall confine myself therefore, to a description of my own solution of the difficulty, the superiority of which, for certain kinds of work at least, I believe now to be undisputed.

Before proceeding to details it may be well to state, that the process is designed and fitted for the reproduction of existing originals only, such as maps and plans, engravings, pen-and-ink drawings, MS. and printed documents, &c., and not for producing portraits or views directly from nature. The problem to be solved may be defined, more accurately, as follows: From a given original existing as a black and white drawing or engraving, to produce by the chemical agency of light, a fac-simile on stone, identical in character with an ordinary lithographic drawing, which has been fitted for the printer.

The first step in the process is the production of a negative, which shall bear the desired relation to the original in size. This is done by placing the latter upon an upright plan-board, and the camera opposite to it, taking care that the plan-board and the ground-glass slide of the instrument are perfectly parallel, and that the distance between them is such as to give a copy of the desired dimensions. The negative picture is then taken in the ordinary way on collodion, but with numerous precautions, so as to secure the best possible result.

Having proceeded thus far, it is necessary to prepare the sensitive surface upon which the positive print from this negative is to be made. All the processes of which anything was known or published up to my time, were based upon the idea that the surface of the stone should be made sensitive to the action of light, and that the photographic picture formed thereon should possess the necessary and peculiar lithographic properties. I deviated from my predecessors in this respect, and struck out a new course, which at once gave superior results. This consisted in sensitizing a sheet of paper in such a way as to make it fulfil similar conditions; and having produced upon it a photograph in lithographic ink adapted for the purpose, the same is transferred to stone by a well-known lithographic operation, and printed in the ordinary way.

To effect this object, a sheet of paper of the best quality is prepared with a solution of gelatine and bichromate of potash in water, to which a quantity of albumen has been added. This mixture is poured into a long narrow trough, and one side of the paper is covered with it, by drawing a sheet over the fluid in the trough, while an assistant presses it into contact with the same by means of a piece of wood of suitable form.

The paper thus coated is carefully dried in the dark, and upon it a positive print from the negative above mentioned is printed by light in the manner practised by photographers. The result is that a brown picture makes its appearance upon the clear bright yellow of the paper, identical in every respect with the original which was copied, unless perhaps a reduction or enlargement in size may have been decided on. It is not however the change in color which makes this picture valuable for photo-lithographic purposes, but rather the alteration in the chemical and physical properties of the organic substances, which form the superficial coating upon the sensitive paper, the nature of which will be understood when the following operations are described. These are technically known as "blacking," "swimming," and "washing off." Blacking an exposed positive has for its object the distribution of an even coating of lithographic transfer ink over its surface. Such an ink is essentially composed of greasy or resinous substances fused together, and blackened with lampblack. For our present purpose it is distributed with the printing roller over the surface of a stone in the press, and upon it the exposed positive print is laid, with the photographic picture downwards, and in contact with the ink. After passing both stone and paper through the press, and separating them, the latter will be found to have brought away

with it an even coating of the lithographic ink, hiding almost totally the photographic delineation from view. The swimming, or as it is also more properly called, "coagulation," is the next step; it is accomplished by letting the blackened print float upon the surface of boiling water, with its uncoated side downwards. The chief result sought to be secured by this operation is the coagulation of the albumen contained in the film. This takes place, due to the action of the moisture and heat together; and in addition to it another advantage is gained by the percolation of the water through the paper, namely, the softening and gelatinization of the gelatine contained in the coating of organic matter under the ink. This change extends only to such portions of the sensitive surface as were protected from the action of light by the negative; those which form the picture suffer no further alteration while the print is swimming, due to the solvent action of water; they do not soften or swell, and demonstrate this fact by remaining depressed, in relation to the other parts of the blackened surface, which rise very perceptibly around them.

After sufficient soaking, we have to remove from this print the superfluous ink which is upon it, our object being to retain that portion only which goes to form the picture. This is effected by placing the wet sheet upon a smooth surface, and applying a moderate amount of friction to it by means of a wet sponge, or similar substance. Gradually the ink leaves those portions of the blackened print which represent the white parts of the original; but the exposed or positive portions retain it with great tenacity, owing to the chemical alteration which the light has effected in them. Eventually we find ourselves possessed of a copy of the original in lithographic ink, which is washed in abundance of water, and dried.

The ink upon the print, the preparation of which has been just described, is transferred to stone by a process more or less thoroughly understood by ordinary lithographers, occurring as it does not unfrequently in the routine of their business. It consists in laying the print, inverted, upon a clean and smooth lithographic stone, which has been slightly warmed, and passing it through the press. The consequence is, that the greasy lithographic ink passes over to the stone, and forms there a chemical picture which is reversed, and from which, after it has been properly "etched" or "prepared," impressions can be taken in the press.

The coagulated albumen, upon which some stress has been laid, plays an important part during this operation of transferring; for, owing to its insoluble nature, no amount of washing can remove it

from the surface of the paper; and after the print is washed off and dried, the inky picture is found to rest, as it were, upon a sheet of albumenized paper. This is damped slightly before laying it upon the stone, and, when the heavy pressure of the press is brought to bear upon it, the albumen shows an amount of adhesiveness sufficient to make it stick fast, and prevent any shift, or doubling of the lines, until the stone and print have been carried through the press as often as the operator thinks necessary.

The latest application which has been made of this process, is one to which I attach much importance; I refer to the illustration of a Prussian Government work, descriptive of the expedition which that state sent a few years ago to Japan, China, and Siam. I am happy in being able to lay the plates belonging to the first part of this work before the members of your Society. They consist of twelve small views and six large ones, besides two maps, and are reproductions of pen-and-ink drawings, made by the landscape painter, Mr. A. Berg, who was sent with the expedition. Two of the larger plates are printed in colors, in imitation of water-color drawing, a combination of chromo- with photo-lithography, which is here made for the first time. On the worth of a process of this kind, whereby every touch and every feeling which the artist puts into the creations of his genius, is reproduced in permanent printing-ink, or by means of which rare and costly engravings can be given to the public at a nominal cost, I do not require to dilate. Mr. Berg, whose connection with the Japanese work naturally makes him a severe critic, has expressed his opinion to me in a letter which I value very highly, and I feel that I cannot conclude my remarks better than by quoting the portion of his communication which bears upon this subject. He says:

"The President of the Royal Commission, appointed to superintend the publication of the East-Asiatic Travels, has requested me to express to you his grateful acknowledgments of your great services and disinterested exertions in this work. It gives me the greatest pleasure to be enabled to make this communication to you; and I avail myself of the opportunity to express to you also, my own sincere thanks for your assistance in this work. You have solved the most difficult problems in this field,—problems, the solution of which I myself despaired of, until the successful result was placed before my eyes. The question, whether pen-and-ink drawings can be multiplied by photo-lithography, and thus made valuable to the artist, is determined by this work."

Mr. Osborne exhibited a portfolio of reproductions of engravings, pen-and-ink drawings, maps, &c., of great excellence, and some of them of rare beauty, fully justifying, in the opinion of the members present, his views of the merits and utility of the process.

President Smith exhibited a piece of lignite from the Dutch Gap Canal, just excavated by the troops of General Butler, to facilitate the operations carried on against Richmond.

The stated business of the meeting being called for, it was, on motion of Prof. Cresson, resolved, that the subject of the claim signed "Torricelli" was worthy of the Magellanic Premium.

The members were then required by the terms of the Fund to declare whether they had considered the subject, so as to entitle them to vote; whereupon the members so making declaration voted, by ballot. The ballot-boxes were then scrutinized by the presiding officer, who announced that the vote was unanimous, and in favor of bestowing the premium upon the claimant.

The sealed package was then opened by the President, and the name of Mr. Pliny Earle Chase was read.

PHILADELPHIA, October 1, 1864.

DR. GEORGE B. WOOD,
President of the American Philosophical Society.

DEAR SIR: I offer, for a Magellanic Premium, the discovery of certain new relations between the solar- and lunar-diurnal variations of magnetic force and of barometric pressure.

The experiments upon mechanical polarity, which were exhibited to the Philosophical Society at its meeting of April 1, 1864, and the series of communications to the Philosophical and Royal Societies, of which those experiments formed a part, have shown that the simple aërial and aethereal currents which are produced by the combination of solar and lunar action with rotation, are sufficient to polarize the atmosphere, and through its specific magnetism to impart a directive polar energy to a magnetized needle.

Since the principal agency of the sun in producing currents and barometric fluctuations appears to reside in the heat of its rays, and that of the moon in its differential or tidal attraction, it seems very probable that the ratio of the barometric to the magnetic disturbance of each luminary may be some function of the relative barometrical and tidal effects of the two bodies. This hypothesis is confirmed by the fact that the lunar-diurnal variations, both of the magnet and of the barometer, exhibit two high and two low daily tides, while the solar-diurnal magnetic variation, like the temperature-tide of the barometer, has only one maximum and one minimum in twenty-four hours.

Let $A =$ the tidal-current variation of equilibrium.

$B =$ the diurnal barometric variation.

$M =$ the diurnal magnetic variation.

Let the solar elements be distinguished by A', B', M'; the lunar by A'', B'', M''.

If the modern physical hypotheses are correct, and the forces that produce A, B, and M are all forms of motion, it is probable that some simple relationship may exist between them. In endeavoring to ascertain that relationship, we readily discover that

$$A' < A''$$
$$B' < M'$$
$$B' > B''$$
$$B'' > M''$$

These inequalities, together with the fact that the solar currents are developed in air that is disturbed by the greater attractive energy of the moon, and the lunar currents in air that is disturbed by the more powerful barometric action of the sun, suggest the supposition that B may be a mean proportional between A and M, and that we may therefore have the following equivalent proportions:

$$B' : B'' :: \sqrt{A'\ M'} : \sqrt{A''\ M''}$$
$$A' : A'' :: B'^2\ M'' : B''^2\ M'$$
$$M' : M'' :: B'^2\ A'' : B''^2\ A'$$

From the same considerations, we may readily infer that

$$\frac{B'}{M'} = \frac{A'}{A''} \qquad (1)$$
$$\frac{B''}{M''} = \frac{B'}{B''} \qquad (2)$$

and that, $\therefore$, B'' is a mean proportional between B' and M''.

According to Maj.-Gen. Sabine's tables (St. Helena Obs., vol. ii, p. lxi), there is a solar maximum, measured in parts of the total force,

of +.00095 at noon, and a solar minimum of—.00045 at 11 P. M.,

$$\therefore \quad M' = .0014 \qquad (3)$$

The lunar tide is so modified by rotation, that its true value can perhaps be best ascertained by adding the tides at equal distances from the lunar meridian (op. citat., p. lxii), and taking their average.

LUNAR-DIURNAL MAGNETIC VARIATION, IN MILLIONTHS OF THE TOTAL FORCE.

	0 h.	1 h.	2 h.	3 h.	4 h.	5 h.	6 h.	7 h.	8 h.	9 h.	10 h.	11 h.	12 h
Before Lunar M.,	+5	−1	+4	−2	−5	−5	−6	−3	−2	−1	+14	+15	+16
After " "	+5	−1	−5	−6	−7	−6	+1	+1	−2	+18	+25	+22	+16
Mean Tide, . .	+5	−1	−.5	−4	−6	−5.5	−2.5	−1	−2	+ 8.5	+19.5	+18.5	+16

We thus obtain an average low tide of —.000006 at 4 h., and a high tide of +.0000195 at 10 h., which gives

$$M'' = .0000255 \qquad (4)$$

The values of B, as deduced from the tables presented at the meeting of July 17, are

$$B' = .016 \text{ in.} \qquad (5)$$

$$B'' = .00365 \text{ in.} \qquad (6)$$

Dividing by 28.2821, the mean height of the barometer, in order to obtain results in terms of the total barometric pressure, we have

$$B' = .00056573 \qquad (7)$$

$$B'' = .0001291 \qquad (8)$$

The relative values of A′ and A″ have never been precisely determined. Probably the latest and most correct estimate is the one given in the New American Cyclopedia, Article "Tides," according to which, if

$$KA' = 1 \qquad (9)$$

$$KA'' = 2.55 \qquad (10)$$

Of the homologous quantities contained in (1) (2), it is fairly presumable that those of the greatest magnitude (B′, M′) have been most precisely estimated. Assuming their accuracy, we have:

1. If (8) be supposed correct,

$$M'' = .00002944 \qquad (11)$$

$$\frac{A'}{A''} = \frac{1}{2.475} \qquad (12)$$

2. If (4) be supposed correct,

$$B'' = .00012 \qquad (13)$$

$$\frac{A'}{A''} = \frac{1}{2.475} \qquad (14)$$

3. If M′ and B″ are required, (4), (9), (10), being supposed correct,

$$M' = .00144 \qquad (15)$$

and the value of B″ is the same as in (13).

Other hypotheses might be made, but these are sufficient for illustration.

Even the widest discrepancy between theory and observation is much less than might have been reasonably anticipated in measurements of such extreme delicacy, and far within the limits of probable error, as will be seen by the following synopsis:

	KA′	KA″	B′	B″	M′	M″
Observed,	1	2.55	.00057	.00013	.0014	.0000255
Theoretical, 1	1	2.475	.00057	.00013	.0014	.0000294
Theoretical, 2	1	2.475	.00057	.00012	.0014	.0000255
Theoretical, 3	1	2.55	.00057	.00012	.00144	.0000255

From the hypothetical formula $B = \sqrt{A\,M}$ we deduce the following values:

	Observ.	Theor. 1.	Theor. 2.	Theor. 3.
K	4374	4374	4374	4499
A′	.000229	.000229	.000229	.000222
A″	.000653	.000566	.000565	.000565

In regard to the first theoretical value of M″, it may be observed that it is very nearly equivalent to the mean between .000032, the extreme excursion of the lunar tide, and .0000255, the mean tide.

"TORRICELLI."

Mr. Chase made some remarks, in explanation of the subject of the premium.

In the fifth century before the Christian era, Leucippus and his disciple Democritus taught that heat is the soul of the world, the principle of life and intelligence, and that space is an infinite plenum, pervaded by material atoms too minute to be perceptible to the senses, which, by their constant motions, unions, and separations, form the beginnings and ends of things. In this theory, which is said to have been borrowed from the priests of Isis and Osiris, we may trace the origin of the modern belief in a universal kinetic æther, and of the attempts to resolve all forces into "modes of motion," which were practically inaugurated by our own countryman, Benjamin Thompson, Count Rumford, and which have been so successfully prosecuted by Carnot, Seguin, Mayer, Colding, Joule, Grove, and their collaborators.

The mutual convertibility of Light, Heat, Electricity, Magnetism, Chemical Affinity, and Vital Energy, may be now regarded as one of the most probable physical hypotheses. Faraday has endeavored also to connect gravitation and magnetism or electric action by experimental results, but in vain. Still, the conviction of such a connection is almost irresistible, and various physicists have given us incidental pointings in that direction. Ampère discovered the magnetic effect of electric currents circulating around iron bars; Arago, whose experiments were repeated and extended by Babbage, Herschel, Barlow, Christie, and others, showed that simple rotation produces magnetic disturbances which are governed by fixed laws; the distribution of induced magnetism in masses of iron, as determined by Barlow and Lecount, is the same as would follow from the relative centrifugal motions of different portions of the earth, provided the magnetic axis corresponded with the axis of rotation;* Hansteen suspected, and Sabine practically demonstrated, the influence of the sun upon terrestrial magnetism; Secchi ascertained that "the diurnal excursion of the needle is the sum of two distinct excursions, of which the first depends solely on the horary angle, and the second depends, besides, on the sun's declination,"† and that "all the phenomena hitherto known of the diurnal magnetic variations may be explained by supposing that the sun acts upon the earth as a very powerful magnet at a great distance."‡

This hypothesis has been objected to on the ground that it is difficult to understand how any conceivable intensity of solar magnetism, by its simple induction, could produce so great a disturbance as is daily observed. Therefore it will probably follow the fate of the earlier ones, which attributed terrestrial magnetism to one or more powerful magnets lying nearly in the line of the earth's axis, while Barlow's idea that the magnetism is superficial and in some manner induced,§ will still remain in the ascendant. Secchi's conclusions are, however, none the less interesting, and from the fact that magnetism is, like gravity, a central force, varying inversely as the square of the distance, they lend encouragement to those who are endeavoring to find new evidences of the unity of force.

My own experiments and researches have led me to the belief that all magnetism is a simple reaction against a force which disturbs

* This fact was first announced by me, at the Society's meeting, April 15, 1864. See *ante*, p. 367.

† Phil. Mag. [4] 8, 396. ‡ Ibid. 9, 452. § Phil. Trans., 1831.

molecular equilibrium, that the numerical equivalent of the magnetic force is therefore equal and opposite to that of the disturbing force, ($\pm$ M $=$ $\mp$ D), and that all the phenomena of terrestrial magnetism result from tidal and thermal changes in terrestrial gravitation.

Sullivan* and Reinsch† have pointed out the effect of musical vibrations upon the magnetic needle, and I have shown the controlling influence of a purely mechanical polarity.‡ A careful examination of the polarizing thermal and rotation currents,§ will show that the spirals, which they have a tendency to produce, are quasi horizontal cyclones, one set flowing in a nearly constant direction along the magnetic meridian, and the other towards the momentarily shifting solar meridian. The communication of "Torricelli" referred to but one or two of the relations under which these eddies may be viewed; there are others, some of which are perhaps even more curious; and, from the examinations which I have already made, I have deduced the following theses:

I. The daily magnetic variations, though subject to great disturbances, at different hours, show an average approximation to the differences of the gravitation-tidal currents.

Hours from Mean, ...	1h.	2h.	3h.
Means of Theoretical Ratios, . .	.500	.866	1.
" " Observed " . . .	.563	.865	1.

II. Marked indications of an accelerating force are discoverable in the magnetic fluctuations, especially during the hours when the sun is above the horizon.

Hours from Mean, ...	1h.	2h.	3h.
Mean Ratios of Hourly Tidal Differences,	100	73	27
" " " Squares of Hourly Magnetic Differences,	100	74	26

See also Thesis V.

III. There are lunar-monthly barometric and magnetic tides, which may be explained by differences of weight or momentum,‖ occasioned by the combined influences of solar and lunar attraction, and terrestrial rotation.

IV. The solar-diurnal variations of magnetism between noon and

* See De la Rive's Electricity, v. ii, p. 635.
† Phil. Mag. [4], 13, 222.
‡ Ante, p. 359.
§ Ibid., p. 367 sqq.
‖ I believe there can be no weight without some degree of momentum. See Proc. A. P. S., vol. ix, p. 357.

midnight are nearly identical in amount with the variations of weight produced by solar attraction at the same hours.

The ratio of the solar to the terrestrial attraction for any particle at the earth's surface, being directly as the mass, and inversely as the square of the distance ($M \div R^2 = 354{,}936 \div 23{,}000^2$), is .00067. The weight of any particle is therefore increased by this proportionate amount at midnight, and diminished in the same proportion at noon, making a total half-daily variation of .00134 in the atmospheric weight, and consequently, according to my theory, in the terrestrial magnetism.

Theoretical variation, .00134. Observed variation, .00138.

V. The magnetic variations at intermediate hours, between noon and midnight, indicate the influences of an accelerating force, like that of gravity, modified by fluctuations of temperature and by atmospheric or ætherial currents.

Every particle of air may be regarded as a planet revolving about the sun in an orbit that is disturbed by terrestrial attraction and other causes. In consequence of these disturbances, there is an alternate half-daily fall towards the sun, and rise from the sun. By the laws of uniformly accelerated and retarded motions, the mean fall, and the consequent mean magnetic disturbances should occur at $12\text{h.} \div \sqrt{2} = 8\text{h. } 29'$ from midnight.

Theoretical mean, 8h. 29′. Observed mean, 8h. 31′.

VI. Some of the magnetic influences appear to be transmitted instantaneously, through the rapid pulsations of the kinetic æther,—others gradually, through the comparatively sluggish vibrations of the air.

VII. The comparative barometric disturbances of the sun and moon exhibit an approximate mean proportionality between their comparative differential-tidal and magnetic disturbances.

Let the solar differential-tidal force be represented by A′, and the lunar by A″, the respective barometric disturbances by B′ and B″, and the magnetic disturbances by M′ and M″. If M′ and B″ are required, we have

	A′ ÷ A″	B′	B″	M′	M″
Theoretical values,			.00012	.00144	
Observed "	2.55	.00057	.00013	.00140	.0000255.

VIII. The theoretical gravitation-variation of magnetism (Prop. IV) is slightly less, while the theoretical barometric variation (Prop.

VII) is slightly greater than the corresponding observed variation. The excess in one case exactly counterbalances the deficiency in the other, the sum of the theoretical being precisely equal to the sum of the observed variations.

IX. The total daily magnetic variations, like the barometric, can be resolved into a variety of special tides, which may be severally explained by well-known constant or variable current-producing and weight-disturbing forces.

	A	B	A+B	
Hours from Midnight.	Theoretical Gravitation Tide.	Theoretical Differential Solar Tide.	Theoretical Mean Tide.	Observed Mean Tide.
0	—.00067	+.00024	—.00043	—.00043
6	.00000	—.00024	—.00024	—.00023½
12	+.00067	+.00024	+.00091	+.00095

The hours are counted from midnight, in each half-day.

Column A contains the hourly differences from mean weight, attributable to solar gravitation, with changed signs; diminution of weight being accompanied with increase of magnetism, and *vice versa*.

The form of the tide in column B is evidently such as should be determined by solar action. The magnitude of the tide is estimated by comparing the relative amounts of motion down the diagonal and down the arc of a quadrant ($.00067\times[1-(\frac{\pi}{4}-\frac{1}{2})]=.00048$). The mean-tidal difference $[(.00067-.00048)\div 2]$ is very nearly equivalent to the average theoretical inertia-disturbance of weight. The atmospheric inertia at St. Helena, (regarding the fluctuations as uniform between successive hourly observations), produces retardations of 59′, 85′, 26′, and 31′, at 0h., 6h., 12h., and 18h., respectively. The mean retardation is 50′, or $\frac{5}{12}$ of a half-day. The theoretical daily gravity-variation being .00134, the average variation in $\frac{5}{12}$ of a half-day is $.00009\frac{1}{6}$, the mean tidal difference being $.00009\frac{1}{2}$.

The consideration of the moon's disturbance of the atmospheric gravitation, is complicated by the magnitude of its differential attraction, the position of the centre of gravity of the terrestrial system, the varying centrifugal force, and other circumstances involved in the lunar theory. Still there are indications in the following synopsis, of the influence of gravity, sufficiently striking to encourage a hope that our knowledge of the moon's perturbations may be improved by a thorough comparative study of the lunar a tronomical, atmospheric, and magnetic tables.

LUNAR-DAILY DISTURBANCES OF MAGNETIC FORCE AT ST. HELENA, IN MILLIONTHS OF THE TOTAL FORCE.

Hours.	0	1	2	3	4	5	6	7	8	9	10	11	12
Before Lunar M.	+5	—1	+4	—2	—5	—5	—6	—3	—2	—1	+14	+15	+16
After " "	+5	—1	—5	—6	—7	—6	+1	+1	—2	+18	+25	+22	+16
Mean.	+5	—1	—0.5	—4	—6	—5.5	—2.5	—1	—2	+8.5	+19.5	+18.5	+16
Rotation-Tide.	0	0	+4.5	+2	+1	+.5	−3.5	−2	0	−9.5	−5.5	−3.5	0

The above table shows, that

1. The moon's attractive force ($M \div R^2 = .016 \div 60^2 = .000004$) multiplied by the coefficient of its differential attraction (2.55) gives .0000113, which is nearly the same as the mean meridional magnetic disturbance [$(.000005 + .000016) \div 2 = .0000105$].

2. The increase of magnetism at 12h. is nearly equivalent to the attractive force, multiplied by the square of the distance from the centre of gravity of the system, and divided by the square of the earth's radius ($.000004 \times 7707^2 \div 3963^2 = .0000168$).

3. There is a tendency to equality of disturbances on each side of the meridian at 1h. and 8h., as in the solar magnetic tide.

4. The greatest disturbance occurs at the hours of 10h. and 11h. P.M., both in the solar and in the lunar tide.

5. There are some indications of an increase of gravity and decrease of magnetic force when the tidal flow is towards the centre of gravity of the terrestrial system, and *vice versa*.

6. The rotation-tide has the customary quarter-daily phases of alternate increase and diminution.

X. The phenomena of magnetic storms indicate the existence of controlling laws, analogous to those which regulate the normal fluctuations. See Proceedings Amer. Philos. Soc., Oct. 21, 1864.

The foregoing comparisons have been based on General Sabine's discussions of the St. Helena records. It would be desirable, if it were possible, to confirm them by observations at other stations near the equator, but the need of such confirmation is in great measure obviated by the variety of ways in which I have shown the probable connection of gravity and magnetism. At extra-tropical stations, the rotation tide becomes so preponderating that it is difficult to trace the diminished gravitation- and differental-tides, still I shall look confidently to a fuller development of the theory of tidal action, for future additional support to my views.

Pending nomination No. 529, and new nominations Nos. 530, 531, 532, 533, were read.

The annual report of the Finance Committee was read, and the appropriations for the ensuing year, recommended by the Committee were, on motion, ordered to be made, as follows:

Salary of Librarian,	$700 00
Assistant to the Librarian,	360 00
Petty expenses of Library,	50 00
Janitor,	100 00
Binding,	150 00
Journals,	50 00
Hall account,	200 00
Insurance,	200 00
Publications (in addition to the interest of Publication Fund),	800 00
Commissions to Treasurer and all other incidental charges,	590 00
	$3200 00

After which the Society was adjourned.

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MEMBERS ELECTED: 8, 27, 91, 129, 206, 239, 275, 328, 371, 411, 440.

MEMBERS ACCEPT; are presented.

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London, Palæontological Soc., ... 205
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fig. 1. Section at Mont Alto Furnace.

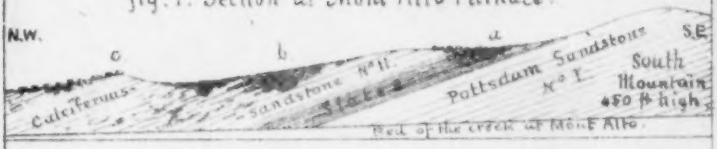

fig. 2. Home Bank.

fig. 3. Home bank.

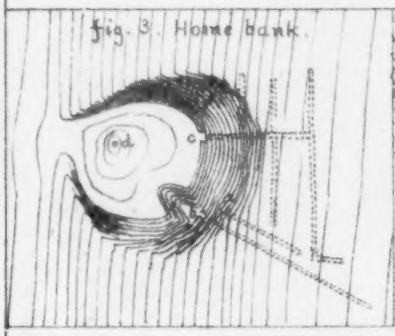

fig. 5. Caledonia bank.

fig. 4. Little Mountain ore banks.

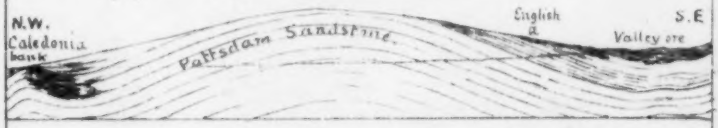

fig. 6 Lower Pond Bank.

fig. 7. Upper Pond Bank.

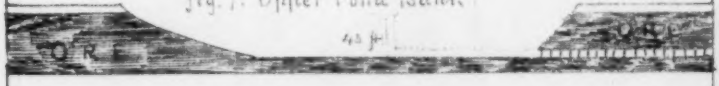

Plate IX.

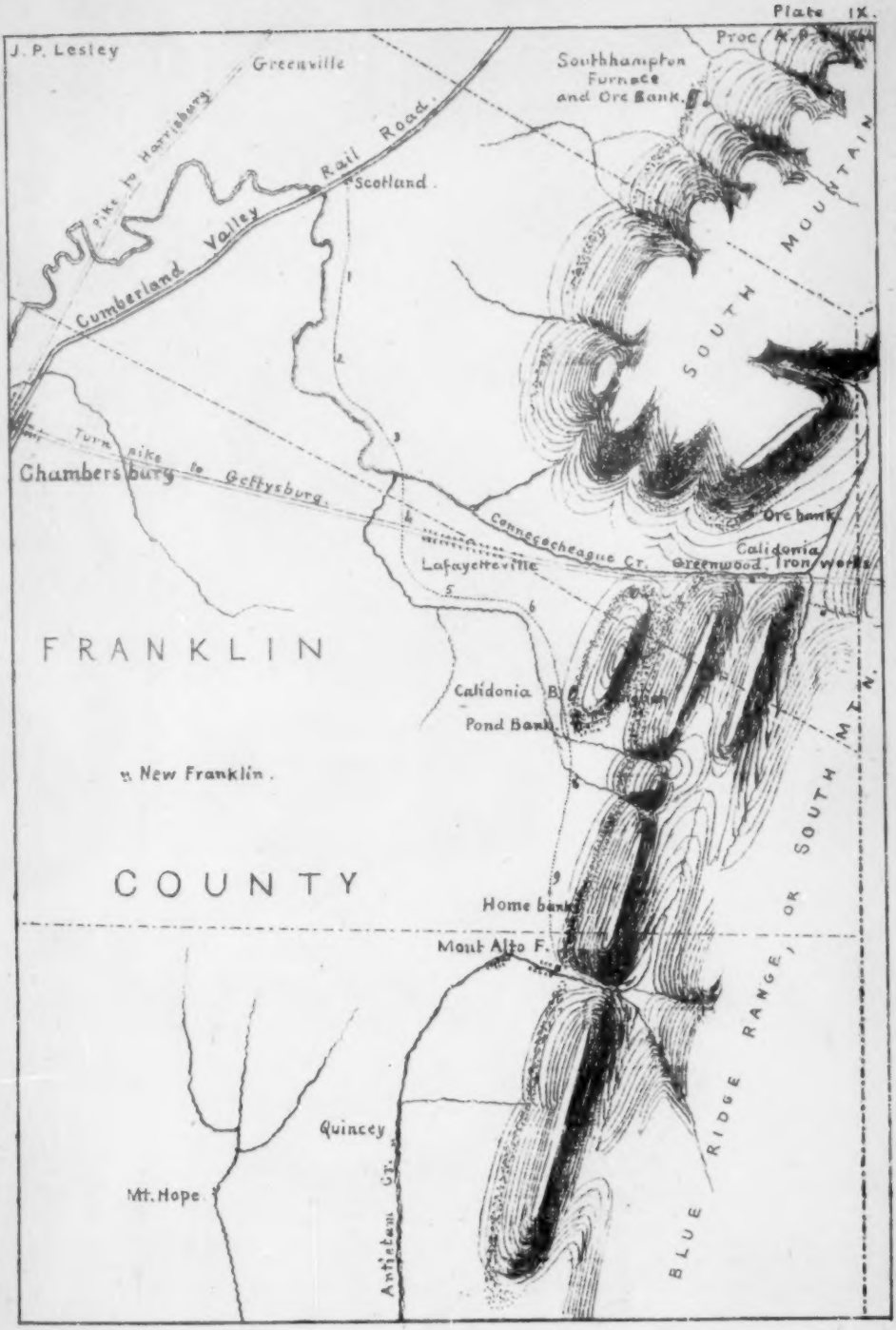
J. P. Lesley
Greenville
Pike to Harrisburg
Rail Road
Scotland
Cumberland Valley
Southhampton Furnace and Ore Bank
Proc
SOUTH MOUNTAIN
Turnpike to Gettysburg
Chambersburg
Connecocheague Cr.
Lafayetteville
Ore bank
Calidonia
Greenwood Iron works
FRANKLIN
Calidonia
Pond Bank
New Franklin
COUNTY
Home bank
Mount Alto F.
SOUTH MT.
BLUE RIDGE RANGE, OR SOUTH MT.
Quincey
Mt. Hope
Antietam Cr.

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fig. 8. View of Caledonia Ore Bank.

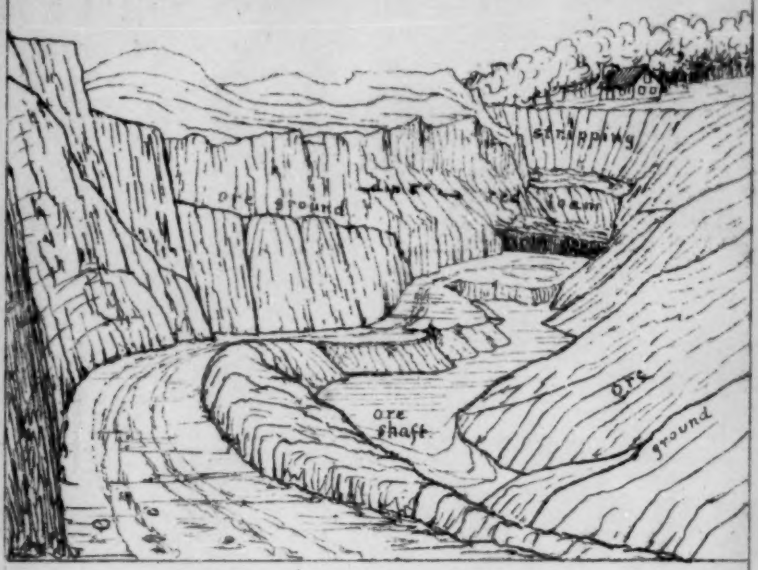
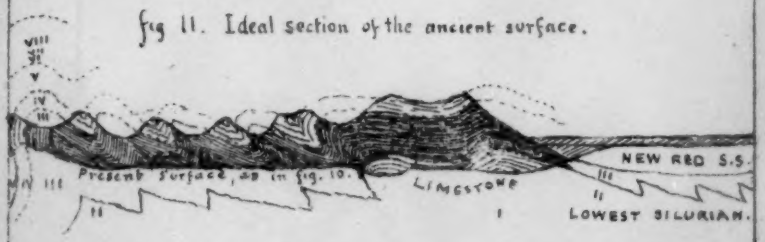


fig. 9. Section across the Cumberland Valley.

fig. 10. Section 10 miles east of Harrisburg.

fig 11. Ideal section of the ancient surface.



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